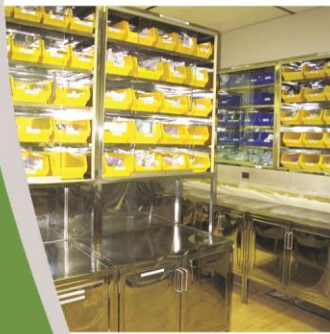
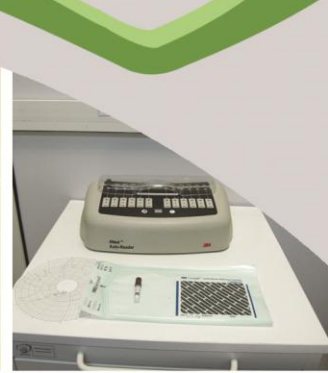
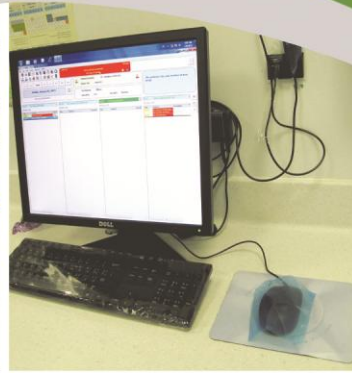




King Saud University  
College of Dentistry



# INFECTION CONTROL GUIDELINES FOR THE COLLEGE OF DENTISTRY



**INFECTION CONTROL  
GUIDELINES  
FOR THE  
COLLEGE OF DENTISTRY  
KING SAUD UNIVERSITY**

**2013G (1434H)**

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## List of Used Abbreviations

**ACIP:** Advisory Committee on Immunization Practices

**ACH:** Air Changes/Hour

**ADA:** American Dental Association

**AFB:** Acid-Fast Bacilli

**AIA:** American Institute of Architects

**AIDS:** Acquired Immune Deficiency Syndrome

**AIIR :** Airborne Infection Isolation Room

**ALT:** Alanine Aminotransferase (test)

**Anti-HBc:** Antibody to Hepatitis B Core Antigen

**Anti-HBe:** Antibody to Hepatitis Be Antigen

**Anti-HBs:** Antibody to Hepatitis B Surface Antigen

**Anti- HCV:** Antibody to Hepatitis C

**Anti-HEV:** Antibody to Hepatitis E

**ART:** Antiretroviral Therapy

**BAMT:** Blood Assays For Mycobacterium Tuberculosis

**BCG:** Bacillus Calmette-Guérin (vaccine)

**BIs:** Biologic Indicators

**BSE:** Bovine Spongiform Encephalopathy

**CDC:** The Centers for Disease Control and Prevention

**cfu:** colony-forming unit

**CJD:** Creutzfeldt-Jakob Disease

**CMV:** Cytomegalovirus

**CSSD:** Central Sterilization and Supply Department

**DHCP:** Dental Health Care Personnel

**DNA:** Deoxyribonucleic Acid

**DUWLs:** Dental Unit Waterlines

**DTP:** Diphtheria-Tetanus-Pertussis

**DT:** Diphtheria-Tetanus (vaccine)

**DTaP:** Diphtheria-Tetanus-acellular Pertussis (vaccine)

**EBV:** Epstein-Barr virus

**EHC:** Employee Health Clinic

**EPA:** Environmental Protection Agency

**EPP:** Exposure Prone Procedures

**ER:** Emergency Room

**EU:** Endotoxin Unit

**FDA:** Food and Drug Administration

**GABHS:** Group A Beta-Hemolytic Streptococci

**GNB:** Gram-Negative Bacilli

**HAART:** Highly Active Antiretroviral Therapy

**HAV:** Hepatitis Virus type A

**HBV:** Hepatitis Virus type B

**HBcAg:** Hepatitis B core Antigen

**HBeAg:** Hepatitis Be Antigen

**HBsAg:** Hepatitis B Surface Antigen

**HCP:** Health Care Personnel

**HCV:** Hepatitis Virus Type C

**HDV:** Hepatitis Delta Virus

**HEPA:** High Efficiency Particulate Air (filter)

**HEV:** Hepatitis Virus Type E

**Hib:** Haemophilus influenzae type b

**HIV:** Human Immunodeficiency Virus

**HSV:** Herpes Simplex Virus

**HSV 1:** Herpes Simplex Virus Type 1

**HSV 2:** Herpes Simplex Virus Type 2

**HVAC:** Heating, Ventilation, and Air Conditioning

**HVE:** High-Volume Evacuator

**HZV:** Herpes Zoster Virus

**ICD:** Irritative Contact Dermatitis

**Ig:** Immunoglobulin

**IgG:** Immunoglobulin class G

**IgM:** Immunoglobulin class M

**IgM Anti-HBc:** Immunoglobulin class M Antibody to HBcAg

**IGRA:** Interferon Gamma Release Assay (test)

**IM:** Intra- Muscular

**IPV:** Inactivated Polio Vaccine

**IV:** Intra-Venous

**KDF:** Kinetic Degradation Fluxion

**LAA:** Laboratory Animal Allergy

**LAIV:** Live Attenuated Influenza Vaccine

**LFT:** Liver Function Test

**LTB1:** Latent TB Infection

**MCV4:** Quadrivalent Meningococcal Conjugate Vaccine

**MDR:** Multi-Drug Resistant

**MDRTB:** Multi-Drug-Resistant Tuberculosis

**MDROs:** Multi-Drug Resistant Organisms

**MEC:** Minimum Effective Concentration

**MMR:** Measles, Mumps And Rubella (vaccine)

**MOH:** Ministry of Health

**MPSV:** Meningococcal Polysaccharide Vaccine

**MRSA:** Methicillin Resistant Staphylococcus Aureus

**MSDS:** Material Safety Data Sheet

**NADL:** National Association of Dental Laboratories

**Ni/Cd:** Nickel/ Cadmium

**NIOSH:** National Institute of Occupational Safety and Health

**OI:** Opportunistic Infections

**OPIM:** Other Potentially Infectious Materials

**OPV:** Oral Polio Vaccine  
**OSHA:** The Occupational Safety and Health Administration  
**PCR:** Polymerase Chain Reaction (test)  
**PEP:** Post-Exposure Prophylaxis  
**PHN:** Post Herpetic Neuralgia  
**PI:** Protease Inhibitors  
**PME:** Presidency of Meteorology and Environment  
**PPE:** Personal Protective Equipment  
**PSGN:** Post-Streptococcal Glomerulonephritis  
**RNA:** Ribonucleic Acid  
**RSV:** Respiratory Syncytial Virus  
**SARS:** Severe Acute Respiratory Syndrome  
**SC:** Sub-Cutaneous  
**SP:** Standard Precautions  
**TB:** Tuberculosis  
**Td:** Tetanus –diphtheria (vaccine)  
**Tdap:** Tetanus-diphtheria-acellular pertussis (vaccine)  
**TEWL:** Transepidermal Water Loss  
**TFM:** Tentative Final Monograph (FDA testing criteria)  
**TIG:** Tetanus Immune Globulin  
**TIV:** Trivalent Influenza Vaccine  
**TST:** Tuberculin Skin Test  
**VAPP:** Vaccine-Associated Paralytic Poliomyelitis  
**vCJD:** variant Creutzfeldt-Jakob Disease  
**VRE:** Vancomycin-Resistant Enterococci  
**VZIG:** Varicella-Zoster Immune Globulin  
**VZV:** Varicella-Zoster Virus  
**WHO:** World Health Organization  
**ZOE:** Zinc Oxide Eugenol

## EXECUTIVE SUMMARY

The Infection Control Guidelines for the College of Dentistry, King Saud University, 2012, present the requirements for the practice of infection control in the various departments of the College, as approved by the College Board of the College of Dentistry. These guidelines aim to guide policy makers and educators within the College of Dentistry in formulating the policies and procedures for the various clinics and departments, and in determining the content of infection control educational material. This document supercedes any previous infection control documents published by the College of Dentistry. It has updated the information in previous guidelines and expanded their scope to provide more comprehensive coverage of infection control issues, and provides more detailed guidance on most aspects of the topics covered.

These guidelines address the requirements for protection of dental health care personnel and patients from cross-contamination, through providing information on the use of standard precautions and isolation-based precautions, as well as providing guidance on control measures of different infectious diseases of major concern in dentistry, vaccination of dental healthcare personnel (DHCP), management and documentation of occupational exposure, work restriction and management of job-related illnesses, hand hygiene, the use of personal protective equipment, acceptable methods of decontamination of the various classes of patient care items, environmental infection control, work practice controls, engineering controls, and the management of medical waste.

The guidelines for acceptable design of the dental clinics and dental units from an infection control perspective are also presented, as well as approved methods for maintaining acceptable quality of dental treatment water. Specific issues of clinical precautions during operation are also addressed, as well as guidelines for infection control in the specific practices of radiology and prosthodontics and the specific areas of the dental laboratory, and research animal facilities. Detailed guidelines are also presented regarding the design of the central sterilization and supply department (CSSD), attire of the CSSD staff, workflow, and instrument processing and monitoring. Guidelines are also presented for a standard-

ized program for acquisition of devices and materials.

In formulation of these guidelines, relevant resources issued by the Centers for Disease Control and Prevention (CDC) were referred to extensively. Such resources included, but were not limited to, guidelines for infection control in dental health-care settings, disinfection and sterilization in healthcare facilities, environmental infection control, infection prevention in outpatient settings, and hand hygiene in health care settings, as well as recommendations on immunization of health-care personnel, preventing needlestick injuries in health care settings, and management of occupational exposures. The Bloodborne Pathogens Standard of the Occupational Safety and Health Administration (OSHA) was also referred to. In matters not fully addressed by the CDC or OSHA, information was supplemented from guidelines, directives, or resources published by other national and international governmental bodies and academic institutions. Information was also obtained from resources published by the World Health Organization (WHO), and professional associations such as the American Dental Association (ADA), Organization for Safety and Asepsis Procedures (OSAP), Infection Control Nurses Association, and the American Academy of Oral and Maxillofacial Radiology.

Due to the time lapse since many of the guidelines, articles published in peer-reviewed journals were also referred to in matters which were not controversial. To the extent possible, papers published within the past ten years were used. However, older articles were also referred to in order to highlight their findings if they were of continued relevance, such as the demonstration of interactions between disinfectants and dental materials or the demonstration of spread of contamination by particular routes. The latest editions of established textbooks in the field were also used if they provided useful information not available in the latest guidelines. If conflicting recommendations were encountered, guidelines were given precedence over individual published papers or books.

For matters of national significance, information relating to epidemiology of disease in Saudi Arabia was obtained from the most recent articles published in peer-reviewed journals or from WHO or Saudi Arabian Ministry of Health (MOH) resources. For guidelines on work restrictions applied to DHCP and waste management, the directives of the MOH

and the Infection Control and Prevention Manual of the Gulf Cooperation Council (GCC) and Center for Infection Control (2009) were the main resources.

In matters which the developers of the guidelines felt were not sufficiently addressed in the published literature (wearing of head covers in the clinics and acceptable length of nails for DHCP), the available information regarding the topics was presented to the members of the Infection Control Unit and, after open discussion within the Unit, the Unit reached its conclusions which were included in these guidelines.

For dissemination of these guidelines, this document is to be made available on the College of Dentistry website. Based upon the information contained within this document, policies and procedures relevant to the various clinics, departments, or laboratories are to be developed by the Legislative Committee of the Infection Control Unit in conjunction with the respective administrative heads. The policies and procedures will then need to be approved by the Infection Control Unit. Subsequently, every staff member, student, or employee within the College of Dentistry is to receive a copy of the policies and procedures pertaining to their work situation. The policies and procedures are then to be stressed by periodic lectures or workshops which highlight their content.

These guidelines are to be submitted for external review and are to be updated by the Legislative Committee of the Infection Control Unit of the College of Dentistry within two years of the publication date. For this task, the legislative committee is to include as internal consultants representatives from the various departments of the College, including all academic departments. External consultants may also be referred to for expert or professional advice within their area of expertise.



## INTRODUCTION

Infections present a significant hazard in the dental environment. Patients and all dental health care personnel (DHCP), including dentists, hygienists, assistants, and laboratory personnel, are at significant risk of being exposed to potentially life-threatening pathogenic bacteria, viruses and fungi as consequence of cross-infection during dental treatment.

Many sources of cross-infection exist in the dental office. Saliva, blood, nasal secretions, and other contaminated body fluids may be transmitted between patients via dental instruments and equipment and hands. Dust, contaminated waterlines, clothing, and hair may also harbor pathogenic microorganisms which may be transmitted to patients and DHCP. All such sources of cross-contamination must be considered during implementation of infection control practices in the healthcare environment. Practicing the current methods of sterilization and infection control in the dental office and laboratory will significantly decrease the risk of infectious disease for the patient, dentist, and staff.

Each department and clinic of the College of Dentistry is unique in its working conditions and infection control requirements. Dental health care personnel, therefore, may encounter varying situations and challenges. Hence, even if particular situations are not specified in these guidelines, DHCP are required to exercise their judgment and apply appropriate infection control practices to all situations in which they come in contact with patients, patient materials, instruments, or devices used in patient care.

Although an infection control program cannot guarantee against occupational exposure/transmission, implementation of a well-researched infection control policy, based on the most up to date guidelines and scientific evidence, may aid in reducing the risk of serious infections, and even death, that could result from less careful attention to the critical details of dental asepsis. For this reason, the importance of adherence to the following infection control guidelines in dental practice cannot be overemphasized.

# DISEASE TRANSMISSION

## [1 -11]

An infectious disease is one that is communicable or contagious which means that the disease can be transmitted (spread) in some way from one host to another. Infection control procedures are designed to prevent disease transmission in the dental practice. An understanding of the modes of disease transmission is important in order to prevent such transmission.

### Transmission of Infection in the Dental Environment (Entry of Infections)

Infections may be transmitted in the dental environment via different modes:

#### A. **Parenteral Routes**

*(Transmission via Skin and Mucosa)*

##### **1. Contact Transmission:**

Contact transmission requires physical contact between an infected person or a contaminated surface and a susceptible person (via mucous membrane or non-intact skin-e.g., exposed skin that is chapped, abraded, or shows signs of dermatitis), and the physical transfer of microorganisms. Contact transmission is divided into two subgroups:

- a. Direct contact transmission occurs when microorganisms pass from the infected person to the healthy person via direct physical contact with blood or body fluids. Examples of direct contact are touching, kissing, sexual contact, contact with oral secretions, or contact with body lesions (example is herpetic whitlow caused by transmission of herpes simplex virus).
- b. Indirect transmission involves the transfer of an infectious agent through a contaminated intermediate object or person. Examples include transmission of pathogens to susceptible persons via

the hands or gloves of DHCP which have touched contaminated dental instruments, devices or surfaces, or touched infected tissues, fluids, or colonized body sites of an infected patient. Contaminated dental instruments, and devices may also transmit pathogens indirectly if they are used for another patients without appropriate decontamination.

## **2. Percutaneous Transmission:**

The introduction of a microorganism or an agent of disease into an host through the skin by needle stick or sharps injuries, human bites, or cuts.

## **3. Per mucosal Transmission:**

The introduction of a microorganism or an agent of disease into an host through the mucosa by mucous membrane exposure in the eye, nose, or mouth (e.g. spatter to the eye or mouth).

**Bloodborne Pathogens** are certain pathogens which are carried in the blood and body fluids (such as saliva) of infected individuals, and can be transmitted to others through the above mentioned routes (i.e. contact, percutaneous, and per mucosal transmission). Saliva is of particular concern during dental treatment because it frequently is contaminated with blood. Although blood is not visible in the saliva, it may be present. Because dental treatment often involves contact with blood and always with saliva, bloodborne diseases are of major concern in the dental office. Bloodborne diseases include, but are not limited to, hepatitis B, hepatitis C and acquired immune deficiency syndrome (AIDS).

## **4. Airborne Transmission (transmission by inhalation)**

The smaller particles of an aerosol (0.5 to 10  $\mu\text{m}$  in diameter) and droplet nuclei (see - Definitions of contaminated airborne particles as sources of infection in dental settings) have the potential to penetrate and lodge in the smaller passages of the lungs and are thought to carry the greatest potential for transmitting infections (Aerosol Infection). These fine airborne particles containing pathogens are able to remain infective and may transmit infections over long distances, requiring airborne infection isolation room (AIIR) (see Airborne Precautions) to

prevent its dissemination within a facility. They can also pass through the filters of surgical masks which are not designed to protect against this mode of transmission. A particular respirator (e.g., N-95 respirator) would be needed to afford protection against such transmission. Examples of diseases that are spread through the airborne route include tuberculosis, influenza, pneumonic plague, measles, varicella zoster, severe acute respiratory syndrome (SARS), smallpox (i.e., variola major) and legionnaires disease.

## **B. Enteral Routes**

*(Transmission via the Gastrointestinal Tract)*

### **1. Fecal-oral Transmission:**

Ingestion of food or water contaminated with fecal matter. If proper sanitation (such as handwashing) after use of the toilet are not followed, many pathogens present in fecal matter may be transmitted to others directly or indirectly (contaminated surfaces or food).

### **2. Dental Unit Waterlines:**

Ingestion of water containing pathogenic microorganisms released from the biofilm within dental unit waterlines (transmission of diseases from waterlines could also be through inhalation).

### **Transmission could also be:**

#### **1. Perinatal Transmission:**

The transmission of pathogen from mother to baby during the perinatal period, the period immediately before and after birth. This occurs through the placenta (per mucosal transmission) or by ingestion from the breast milk (enteral route of transmission). Perinatal route is also called vertical transmission.

#### **2. Droplet Transmission:**

(see - Definitions of Contaminated Airborne Particles)

Droplets are generated when an infected person coughs, sneezes, or talks, or during procedures which involve the use of air-water syringes, handpieces and ultrasonic scalers. Droplets containing pathogenic microorganisms have the potential to transmit disease if they contact mucous membranes or unprotected skin (Droplet Infection). Droplet transmission is, technically, a form of contact transmission. However, in contrast to contact transmission, respiratory droplets carrying infectious pathogens transmit infection when they travel directly from the respiratory tract of the infectious individual to susceptible mucosal surfaces of the recipient, generally over short distances.

The maximum distance for droplet transmission is currently unresolved, although pathogens transmitted by the droplet route have not been transmitted through the air over long distances, in contrast to the airborne pathogens. Historically, the area of defined risk has been a distance of less than 3 feet around the patient. However, studies of smallpox and SARS suggest that droplets from patients with these two infections could reach persons located 6 feet or more from their source. It is likely that the distance droplets travel depends on the velocity and mechanism by which respiratory droplets are propelled from the source, the density of respiratory secretions, environmental factors such as temperature and humidity, and the ability of the pathogen to maintain infectivity over that distance.

Organisms transmitted by the droplet route do not remain infective over long distances, and therefore do not require special air handling and ventilation. Surgical masks, eye glasses, gowns and face shields interrupt this mode of transmission. Examples of infectious agents that are transmitted via the droplet route include *Bordetella pertussis*, influenza virus, adenovirus, rhinovirus, *Mycoplasma pneumoniae*, SARS-associated coronavirus, group A streptococcus, *Neisseria meningitidis* and respiratory syncytial virus (RSV).

### **Definitions of Contaminated Airborne Particles**

The main potential sources of airborne contamination during dental treatment are saliva, respiratory secretions and the water from dental unit waterlines. Visible spray created during the use of air-water

syringes, dental rotary instruments, and ultrasonic scalers and droplet generated when an infected person coughs, sneezes, or talks may contain blood, saliva, nasopharyngeal (nasal) secretions, and infectious microorganisms. Contaminated airborne particles could be in the form of droplets, droplet nuclei, spatter, or aerosols.

### ***Droplets***

Droplets are small particles of moisture larger than 5  $\mu\text{m}$  and less than 500  $\mu\text{m}$  in size (intermediate in size between drops and droplet nuclei). These droplets could be projected from the patient by coughing, sneezing, talking, or by splatter from a dental procedure. As the droplet begins to evaporate, the size of the droplet becomes smaller, and it then has the potential to stay airborne or to become reairborne as a dust particle. Dehydration of airborne droplets containing microorganisms leads to formation of Droplet nuclei.

### ***Droplet Nuclei***

Droplet nuclei are the residuals of droplets that, when suspended in air, subsequently dry and produce particles ranging in size from 1–5  $\mu\text{m}$  in diameter. Droplet nuclei can remain suspended in the air indefinitely for long periods of time, and may reach beyond 3 feet of the source of these particles, and even be transported over long distances through the air and ventilation system. These particles can contain potentially viable microorganisms which are protected by a coat of dry secretions. The microorganisms in droplet nuclei persist in favorable conditions (e.g., a dry, cool atmosphere with little or no direct exposure to sunlight or other sources of radiation).

### ***Spatter***

Spatter are visible large-particle droplet of water, saliva, blood, microorganisms, and other debris that makes up the bulk of the spray generated in dental settings. They form airborne particles larger than 50  $\mu\text{m}$  in diameter, and settles out quickly, landing either on the floor, nearby operatory surfaces, dental personnel providing care, or the patient. Spatter particles behave in a ballistic manner when they are generated, i.e. they are ejected forcibly from the operating site and arc in

a trajectory similar to that of a bullet until they contact a surface or fall to the floor. These particles are too large to become suspended in the air and are airborne only briefly. They fall onto surfaces within a 60 cm range of the point of origin.

### ***Aerosols***

Aerosols are small airborne particles that take considerable energy to generate and can stay airborne for an extended periods of time before they settle on environmental surfaces or enter the respiratory tract. Aerosols consist of particles less than 10 microns in diameter, and are not typically visible to the naked eye. However, aerosol droplets can reach up to 50  $\mu\text{m}$  in diameter. Due to their ability to stay airborne, and potential to enter respiratory passages, the greatest airborne infection threat in dentistry comes from aerosols.

## UNIVERSAL PRECAUTIONS AND STANDARD PRECAUTIONS [10, 12-16]

**Universal Precautions** is defined as an approach to infection control. According to the concept of universal precautions, all human blood and certain human body fluids are treated as if known to be infectious for human immunodeficiency virus (HIV), hepatitis virus types B (HBV), and other bloodborne pathogens. The Centers for Disease Control and Prevention (CDC) introduced its universal precautions document in 1986. This was later expanded in scope and referred to as standard precautions. However, The Occupational Safety and Health Administration's (OSHA's) bloodborne pathogen standard retains the term universal precautions.

**Standard precautions** is the term used now by CDC and is defined as the minimum infection prevention practices that apply to all patient care in any setting where healthcare is delivered, regardless of suspected or confirmed infection status of the patient. Standard precautions combine the features of universal precautions and body substance isolation. These precautions are designed to both protect health care personnel (HCP) and prevent HCP from spreading infections among patients, and are intended to prevent skin and mucous membrane exposures. Standard precautions are based on the assumption that every person potentially is infected or colonized with an organism that could be transmitted in a health care setting.

### ***Standard precautions apply to the following:***

1. Blood
2. All body fluids, secretions and excretions (except sweat) regardless of whether they contain blood
3. Non-intact skin
4. Mucous membranes

### ***Standard precautions include the following:***

1. Hand hygiene.



2. Use of personal protective equipments.
3. Safe handling of potentially contaminated instruments and equipments to avoid cross contamination.
4. Environmental control.
5. Proper handling of textiles and laundry.
6. Engineering controls and work practice controls:
  - a. Engineering controls are the primary method to reduce exposures to blood and other potentially infectious materials (OPIM: tissues, or other body fluids) from sharp instruments and needles. These controls are frequently technology-based and often incorporate safer designs of instruments and devices (e.g., self-sheathing anesthetic needles and dental units designed to shield burs in handpieces) to reduce percutaneous injuries.
  - b. Work-practice controls establish practices to protect DHCP whose responsibilities include handling, using, assembling, or processing sharp devices (e.g., needles, scalers, laboratory utility knives, burs, explorers, and endodontic files) or sharps disposal containers. Work-practice controls can include removing burs before disassembling the handpiece from the dental unit, restricting use of fingers in tissue retraction or palpation during suturing and administration of anesthesia, and minimizing potentially uncontrolled movements of such instruments as scalers or laboratory knives.
7. Avoiding occupational exposures.
8. Safe injection practices.
9. Safe disposal of waste.
10. Respiratory hygiene/cough etiquette. The primary components of respiratory hygiene and cough etiquette are as follows:
  - a. covering the mouth and nose during coughing and sneezing;
  - b. using tissues to contain respiratory secretions and promptly

- disposing of them;
- c. offering a surgical mask to people who are coughing to decrease contamination of the surrounding environment;
  - d. performing hand hygiene after contact with respiratory secretions; and
  - e. turning the head away from others and maintaining spatial separation, ideally more than three feet, when coughing.

## TRANSMISSION– BASED ISOLATION PRECAUTIONS

### [3, 10, 12-14, 17-18]

In addition to standard precautions, other measures (e.g., expanded or transmission-based precautions) might be necessary to prevent potential spread of certain diseases (e.g., tuberculosis, influenza, and varicella) that are transmitted through airborne, droplet, or contact transmission (e.g., sneezing, coughing, and contact with skin). When acutely ill with these diseases, patients do not usually seek routine dental outpatient care. Nonetheless, a general understanding of precautions for diseases transmitted by all routes is critical because:

1. some DHCP are hospital-based or work part-time in hospital settings;
2. patients infected with these diseases might seek urgent treatment at outpatient dental offices; and
3. dental health care personnel might become infected with these diseases.

Necessary transmission-based precautions might include patient placement (e.g., isolation), adequate room ventilation, respiratory protection (e.g., N-95 masks) for DHCP, or postponement of nonemergency dental procedures.

While standard precautions (SP) applies to all patients, transmission–based isolation precautions apply to selected patients, based on either a suspected or confirmed clinical diagnosis. It must also be noted that transmission– based isolation precautions are designed to be used in combination with standard precautions. Furthermore, in many instances, the risk of nosocomial transmission of infection may be highest before a definitive diagnosis can be implemented. Therefore, patients with certain signs and symptoms should be isolated while a definitive diagnosis is pending.

Transmission– based isolation precautions are divided into three categories that reflect the major modes of transmission of infectious agents within the health care setting: contact; droplet; and airborne. These isolation categories are to be combined for diseases that have

multiple routes of transmission (Table 1).

**Table 1**

*Conditions and Diseases Requiring Transmission-Based Precautions*

DISEASE/CONDITION	CONTACT PRECAUTIONS	DROPLET PRECAUTIONS	AIRBORNE PRECAUTIONS	DURATION OF PRECAUTIONS
Clostridium difficile	+	NA	NA	DI
Herpes Simplex (Mucocutaneous, Disseminated or Primary, Severe)	+	NA	NA	Until lesions are dry and crust
Influenza Human (Seasonal)	NA	+	NA	Five days DI in people who are immunocompromised
2009 H1N1 Influenza	+	+	+	Seven days from symptom onset or until the resolution of symptoms, whichever is longer
Head Lice (Pediculosis)	+	NA	NA	U four hours
Measles (Rubeola)	NA	NA	+	Four days after onset of rash, except DI in people who are immunocompromised
Methicillin-Resistant Staphylococcus aureus	+	NA	NA	Unresolved issue
Mumps	NA	+	NA	U nine days
Pertussis	NA	+	NA	U five days
Rubella	NA	+	NA	U seven days after onset of rash
Severe Acute Respiratory Syndrome (SARS)	+	+	+	DI plus 10 days after resolution of fever, provided respiratory symptoms are absent or improving
Smallpox (Variola)	+	NA	+	DI until all scabs have crust and separated (three-four weeks)
Tuberculosis (Confirmed)	NA	NA	+	Discontinue precautions only when the patient receiving effective therapy is improving clinically and has three consecutive sputum smears negative for acid-fast bacilli collected on separate days
Varicella Zoster (Chicken Pox)	+	NA	+	Until lesions are dry and crust

+: Use or apply the precaution.  
 NA: Not applicable.  
 DI: Duration of illness (with wound lesions, DI means until wounds stop draining).  
 U: Until time specified in hours or days after initiation of effective therapy.

Source: Siegel, et al. [3], Siegel, et al. [19]

## A. Contact Precautions

Contact precautions are used in addition to standard precautions for specified patients who have poorly controlled body fluids, respiratory secretions or are known or suspected to be infected or colonized with epidemiologically significant microorganisms transmitted by direct or indirect contact. Examples of such infections include:

- Infections or colonization with multi-drug resistant bacteria (e.g. methicillin resistant staphylococcus aureus (MRSA)).
- Enteric infections with a low infectious dose or prolonged environmental survival, including Clostridium difficile.
- Patients infected with: Enterohemorrhagic Escherichia coli, Shigella, hepatitis A, or rotavirus.
- Respiratory syncytial virus, para-influenza virus, enteroviral infections in infants and young children.
- Skin infections that are highly contagious or that may occur on dry skin, including: diphtheria (cutaneous); herpes simplex virus (neonatal or mucocutaneous); impetigo; major (noncontained) abscess, cellulites, or decubiti; pediculosis (lice); scabies; staphylococcal furunculosis in infant and young children; zoster; viral /hemorrhagic conjunctivitis; viral hemorrhagic fevers and group A streptococcal major skin, burn, or wound infection.
- In dental clinic, contact precautions are applied for patients who have uncontrolled wound drainage.

### ***Patient Isolation Requirements***

- Patients should be treated in a private room or clinic when available, or grouped as roommates with other patients who are infected or colonized with the same pathogen.
- Patients must be physically separated (greater than one meter apart) from each other.
- Patients on contact precautions should not be placed in the same room or clinic with patients who have conditions that may increase

the risk of adverse outcome from infection (i.e., those who are immunocompromised or have open wounds).

- All standard precautions should be applied.
- Personal protective equipment (PPE) (gown and gloves) should be worn upon entry to the clinic or room and whenever contacting the patient or potentially contaminated areas surrounding the patient. Before exiting the clinic or room of the patient, PPE should be removed in a manner that prevents contamination of underlying clothing and skin, and discarded. Appropriate hand hygiene should then be immediately performed (see sections on “HAND HYGIENE” and “PERSONAL PROTECTIVE EQUIPMENT”).
- Movement and transport of the patient from the clinic or room should be undertaken for medically essential purposes only.
- If the patient is transported out of the clinic or room, the necessary precautions must be maintained to minimize the risk of transmission of microorganisms to DHCP and other patients, or contamination of environmental surfaces or equipments (infected or colonized areas of the patient’s body should be contained and covered).
- Prior to transporting patients on contact precautions, any contaminated PPE should be removed and disposed of appropriately, and appropriate hand hygiene performed.
- When possible, patient care equipment should be restricted to a single patient. If use of common equipment or items is unavoidable, then the same guidelines governing sterilization and disinfection of reusable items in the dental setting apply (see section on “CHEMICALS USED FOR DISINFECTION AND STERILIZATION IN DENTISTRY- Classification of Items and Surfaces for Decontamination”).
- Clinics and rooms of patients subject to contact precautions should be prioritized for frequent cleaning and disinfection.

### ***Discontinuing Contact Precautions***

Contact precautions may be discontinued under the following conditions:

1. The patient is no longer considered infectious based on clinical

- and/or laboratory data.
2. The patient meets specific decolonization criteria.
  3. The isolation is discontinued by the infection control team.

## B. Droplet Precautions

In addition to standard precautions, droplet precautions should be applied for patients known or suspected to have serious illnesses transmitted by large particle droplets. Examples of such illnesses include:

- Invasive haemophilus influenza type b disease, including meningitis, pneumonia, and sepsis
- Invasive Neisseria meningitidis disease, including meningitis, pneumonia, and sepsis.
- Other serious bacterial respiratory infections spread by droplet transmission, including: diphtheria (pharyngeal); Mycoplasma pneumonia; pertussis; pneumonic plague; streptococcal (group a) pharyngitis; pneumonia, or scarlet fever in infants and young children.
- Serious viral infections spread by droplet transmission including: adenovirus infection; influenza; mumps; parvovirus b19 infection; and rubella.

Droplet precautions must be implemented to prevent the transmission of pathogens spread through close respiratory or mucous membrane contact with respiratory secretions. Generally, special ventilation requirements are not required to prevent droplet transmission.

### ***Patient Isolation Requirements***

- Patient should be placed in a private room when available.
- Patients on droplet precautions should not be placed in the same room with patients who have conditions that may increase the risk of adverse outcome from infection (i.e., those who are immunocompromised or have open wounds).
- Patients should be physically separated (i.e., greater than one me-

ter apart from each other.

- All standard precautions should be applied, including having the patient follow respiratory hygiene/cough etiquette.
- A surgical mask should be worn when working within one meter of the patients.
- Movement and transport of the patient from the room should be undertaken for medically essential purposes only.
- If transport or movement is necessary, dispersal of droplet nuclei from the patient should be minimized by placing face mask on the patient, if possible.

### ***Discontinuing Droplet Precautions:***

Droplet Precautions may be discontinued under the following conditions:

1. The patient is no longer considered infectious based on clinical and/or laboratory data.
2. The isolation is discontinued by the Infection Control team.

## **C. Airborne Precautions**

Airborne precautions are implemented to prevent transmission of infectious agents that remain infectious across long distances when suspended in the air, through aerosolization. Airborne precautions should be used, in addition to standard precautions, when treating patients known or suspected to have serious illnesses transmitted by airborne droplet nuclei. Examples of such illnesses include:

- Measles (Rubeola).
- Varicella (including disseminated zoster).
- Tuberculosis (including pulmonary & laryngeal tb).

### ***Patient Isolation Requirements:***

1. Patient should be placed in an airborne infection isolation room (AIIR) that has been constructed in accordance with current guidelines



- At least six 6 or 12 air changes per hour should take place.
- Room should be supplied with negative pressure (air flows under the door gap into the room).
- Exhaust of air should be directly from the room to the outside of the building or recirculation of air should take place through a high efficiency particulate air (HEPA) filter. The AIIR door should be kept closed when not required for entry and exit.
- When an AIIR is not available, the patient should not be treated and should be referred to a facility that has an available AIIR.

## 2. Respiratory Protection:

- A fit tested respiratory protection (N95 or higher level respirator) should be worn when entering the room.
  - N95 disposable respirators are nonpowered, air-purifying, particulate-filter respirators.
  - The N (not resistant to oil) series respirators are available with filtration efficiencies of 95% (N95), 99% (N99), and 99.7% (N100) when challenged with 0.3  $\mu\text{m}$  particles.
- To assure a good seal of the mask with the face, a deep breath should be taken. Mask should collapse during inhalation and expand during exhalation.
- Susceptible persons should not enter the room of patients known or suspected to have measles (Rubeola) or Varicella (chickenpox) if other immune caregiver is available.
- Masks should only be removed AFTER leaving the room.

- ## 3. Movement and transport of the patient from the room should be limited to essential purposes only. If transport or movement is necessary, dispersal of patient droplet nuclei should be minimized by placing a surgical mask on the patient, if possible.

4. All standard precautions should be applied, including having the patient follow respiratory hygiene/cough etiquette.

### ***Discontinuing Airborne Precautions***

Airborne precautions may be discontinued under the following conditions:

1. The patient is no longer considered infectious based on clinical and/or laboratory data.
2. For pulmonary TB patients, three (3) negative sputum smears are obtained usually after 2 weeks from starting effective treatment.
3. The isolation is discontinued by the infection control team.

**NOTE:** For patients with diseases transmitted by multiple routes, additional isolation requirements should be followed in addition to airborne precautions. For example, for varicella zoster (chicken pox) or disseminated varicella zoster (shingles), contact precautions should be followed as well as airborne precautions.

## INFECTIOUS DISEASES OF MAJOR CONCERN TO DENTAL HEALTH CARE PERSONNEL

[6, 10, 20-21]

Various infectious diseases may be transmitted in the dental environment (Table 2). Microorganisms of concern include hepatitis virus types A, B, and C, herpes simplex virus types 1 and 2, human immunodeficiency virus (HIV), *Mycobacterium tuberculosis*, cytomegalovirus, staphylococci, streptococci, and a number of other viruses and bacteria. A thorough medical history should be obtained from all patients. Specific questions about medications, current illnesses, hepatitis, recurrent illnesses, unintentional weight loss, lymphadenopathy, oral soft tissue lesions, or other infections should be included. Medical consultation may be indicated when a history of active infection or systemic disease is elicited.

Transmission of bloodborne pathogens (e.g., HBV, HCV, and HIV) in dental health-care settings can have serious consequences. Exposure to infected blood can result in transmission from patient to DHCP, from DHCP to patient, and from one patient to another. The opportunity for transmission is greatest from patient to DHCP, who frequently encounter patient blood and blood-contaminated saliva during dental procedures.

For DHCP to pose a risk for bloodborne virus transmission to patients, DHCP must 1) be viremic (i.e., have infectious virus circulating in the bloodstream); 2) be injured or have a condition (e.g., weeping dermatitis) that allows direct exposure to their blood or other infectious body fluids; and 3) enable their blood or infectious body fluid to gain direct access to a patient's wound, traumatized tissue, mucous membranes, or similar portal of entry. Although an infected DHCP might be viremic, unless the second and third conditions are also met, transmission cannot occur.

**Table 2***Representative Infectious Diseases in Dentistry*

Agent/ Disease	Routes	Incubation Period	Estimated Survival at Room Temperature
Bacterial			
Mycobacterium tuberculosis	Saliva Sputum	To 6 mo	Months
Staphylococcus aureus Staphylococcal infections	Saliva Exudates Skin	4-10 days	Days
Streptococcus pyogenes Streptococcal Wound infections Endocarditis	Open wound Bloodborne	1 day-1 wk	Hours-days
Treponema pallidum Syphilis	Direct contact with lesions	1-10 wk	Seconds
Viral			
Respiratory viruses Flu colds	Saliva Secretions	1-14 days	Hours
Hepatitis A virus Hepatitis A	Feces Saliva Blood	15-40 days	Days
Hepatitis B virus Hepatitis B	Blood Saliva Semen	50-180 days	Months
HCV	Blood Saliva Sexual contact	30-150 days	Hours-days
HIV	Blood Semen Secretions	To 11 yr	Days
Herpes simplex I and II Recurrent herpes Whitlow Conjunctivitis	Saliva Secretions	2 wk	Minutes

Source: modified from Nisengard and Newman [21]

## Hepatitis [4]

Hepatitis, which is an inflammation of the liver, varies in seriousness from a minor flulike illness to a fatal liver disease. The severity of the disease depends on the type of hepatitis virus involved and the ability of the host to resist the disease. Early symptoms of hepatitis often include loss of appetite, nausea and vomiting, jaundice (a yellowish discoloration of the skin and eyes, caused by the color of excess liver bile in the blood), and fever.

There are at least four types of **viral hepatitis**, each of which is caused by a different virus: hepatitis A virus, hepatitis B virus (HBV), hepatitis C virus (HCV), hepatitis D virus (HDV), and hepatitis E virus (HEV).

### **Hepatitis A**

**[4, 6-7, 13, 22-24]**

Hepatitis A, formally known as infectious hepatitis, is caused by Hepatitis A virus (HAV) which is a small (27 nm) RNA virus. This is one of the less serious forms of hepatitis.

#### ***Epidemiology:***

Hepatitis A commonly occurs in developing countries where sewage disposal measures and food hygiene is unsatisfactory. Children and young people are most often infected. In the Saudi population, it has been reported to range from 52.4% in young children to 80.0% in adults with a steady increase with increasing age. Other factors associated with significant increase in prevalence were found to be low level of education of parents, low socio-economic status, and rural dwelling (vs. urban)

#### ***Characteristic Features of the Causative Microorganism:***

Humans are the only natural host. The incubation period of Hepatitis A is 15-40 days. Depending on the environmental conditions, the virus can be stable in the environment for months. It can remain stable and infectious at low pH and moderate temperatures, and is inactivated by ultraviolet light, high temperatures, formalin and chlorine.

### ***Transmission of the Disease:***

Hepatitis A is not a bloodborne infection. It is spread via the fecal/oral route, most commonly through contaminated food and water and by direct person to person contact. It is rarely transmitted by needlestick injuries.

### ***High Risk Groups:***

- Inhabitants of day care centers.
- International travelers.
- Intravenous drug users.
- Homosexuals.
- Persons with chronic liver disease.
- Persons drinking contaminated water or eating raw or inadequately cooked shellfish.

### ***Clinical Features:***

Patients with Hepatitis A may manifest sudden onset of fever, malaise, anorexia, nausea, abdominal discomfort, inflammation of the liver and jaundice. Infections with HAV are either asymptomatic or mild in young children. In contrast, approximately 70% of adults and older children manifest jaundice and other symptoms. Chronic infection does not occur. No HAV carrier state exists. Patients are infectious before the onset of symptoms during the prodromal phase and just before the onset of clinical disease.

Some patients continue to excrete HAV in stool during weeks 1-3 of illness, and HAV may also be present in saliva throughout this period. HAV infection is self limiting and recovery provides lifelong protection against recurrent disease.

### ***Diagnosis:***

The diagnosis of acute Hepatitis A is confirmed by finding anti HAV of immunoglobulin M (IgM) in serum collected during the acute or early phase of the disease. The antibodies persist for 4-6 weeks and are then replaced by high concentration of IgG antibodies which remain detectable in serum thereafter confirming lifelong protection against disease.

### ***Prophylaxis:***

- Passive immunization (post exposure use of Immunoglobulin-Ig): In health care setting, immunoglobulin can be given, preferably within 2 weeks after exposure.
- Active immunization (vaccination): Vaccine is available for long term prevention of hepatitis A infection in person two (2) years of age and older. It is given in two (2) doses within 6-12 months interval.

### ***Control Measures:***

In addition to standard precautions, contact precautions are recommended for diapered and incontinent patient for one week after the onset of symptoms. Health care personnel with Hepatitis A should be restricted from patient contact and contact with patient's environment for 7 days after onset of jaundice.

### ***Management of Exposures to HAV:***

Personnel who have had direct fecal-oral exposure to excretions from a patient incubating hepatitis A should be given a single dose of immunoglobulin (0.02 ml/kg up to 2ml) intramuscularly as soon as possible after exposure. Administration 14 days after an exposure is unlikely to be beneficial and hence is not indicated. Prophylaxis with Ig for all personnel who take care of patients with hepatitis A, other than as suggested above, should not be given.

## ***Hepatitis B***

***[4-7, 10, 13, 16, 21-22, 25-37]***

Hepatitis B is a serious disease that may result in prolonged illness. It is caused by hepatitis B virus (HBV) which is a 42 nm enveloped DNA virus that infects and multiplies in human liver cells and is released during the course of an infection in high numbers into the bloodstream and other body fluids. A variety of ultimate outcomes of this disease exist, including a carrier state, liver cirrhosis, acute hepatitis, primary liver cancer, and death.

Careful medical histories will usually reveal approximately 20 percent of individuals who have had hepatitis B. It is strongly suggested that all patients be presumed to be active hepatitis B carriers. The ethical, legal and financial costs of a dentist developing hepatitis B are very serious, including transmission to spouses, vertical transmission to newborn offspring, as well as transmission to patients and staff.

### *Epidemiology:*

Hepatitis B is a major health problem worldwide. Hepatitis B has high endemicity with about 10% to 20% in Southeast Asia, China, parts of the Middle East, and sub Saharan Africa. In contrast, the endemicity is low in Western Europe, the United States, Canada, New Zealand, and Australia, with only a 0.1% to 2%. Globally, approximately 2 billion people have been infected with about 350-400 million people being chronic carrier of the virus. Approximately 90% of HBV carriers live in less developed countries. HBV is the most frequent cause of chronic hepatitis in the world HBV is also associated with about 80% of the cases of primary liver cancer. There are about 1-1.5 million deaths attributable to hepatitis B sequelae each year. Overall mortality rates for reported cases generally do not exceed 2%.

In the past 15 years, studies have shown reductions in the prevalence of hepatitis B in Saudi Arabia. Reported prevalence rates in adults varied from 1.5 - 9.7 % . The results varied according to age, and nationality of the subjects, as well as region of residence. Patients attending a hospital in the Jizan region (for any reason) had the highest prevalence reaching 9.7 % , and Yemeni and Pakistani nationals were found to have the highest prevalence rates among the different nationalities. Prevalence among foreign nationals was found to be lower than in their respective countries probably due to mandatory screening of all expatriates.

Prevalence rates tended to increase with increasing age. In children, the prevalence rate was reported as 0.3- 0.9 % (down from earlier reports of 6.7 %). The rate dropped between 1989-1997 (after implementation of vaccination). The low prevalence of hepatitis B surface antigen (HBsAg) in children, provides evidence for the effective-



ness and efficacy of the integration of hepatitis B vaccination into the extended program of immunization in Saudi Arabia.

### ***Characteristic Features of the Causative Microorganism:***

Humans are the only natural host. The incubation period of Hepatitis B virus is long: 50-180 days. The virus has three components that are important antigens; one on its surface (HBsAg) and two on the inside (HBcAg and HBeAg). Several well-defined antigen-antibody systems have been described for HBV infection (Table 3). Hepatitis B virus has been demonstrated to survive in dried blood at room temperature on environmental surfaces for one week and longer.

The virus can be killed or inactivated by commonly used methods of sterilization and disinfection provided that the killing agent comes into direct contact with the virus. Such methods include:

- Steam autoclave.
- Ten (10) minutes exposure to 1:100 diluted bleach.
- Exposure to 1:16 diluted phenolic glutaraldehyde.
- Exposure to 75 ppm iodophor.
- Exposure to 70% isopropyl alcohol.

(see section on CHEMICALS USED FOR DISINFECTION AND STERILIZATION)

**Table 3**

### ***Hepatitis B Terminology***

Abbreviation	Term	Comments
HBV	Hepatitis B virus	Etiologic agent of "serum" or "long-incubation" hepatitis; also known as Dane particle
HBsAg	Hepatitis B surface antigen	Surface antigen(s) of HBV detectable in large quantity in serum; several subtypes

Abbreviation	Term	Comments
HBeAg	Hepatitis Be antigen	Soluble antigen; antigen correlates with HBV replication, higher titer HBV in serum, and high infectivity of serum
HBcAg	Hepatitis B core antigen	No commercial test available
Anti-HBs	Antibody to HBsAg	Indicates past infection with, and immunity to HBV, passive antibody from HBIg, or immune response from hepatitis B vaccine
Anti-HBe	Antibody to HBeAg	Presence in serum of HBsAg carrier suggests lower titer of HBV and lower infectiousness of the patient
Anti-HBc	Antibody to HBcAg	Indicates past infection with HBV at some undefined time
IgM Anti-HBc	IgM class antibody to HBcAg	Indicates recent infection with HBV; tests positive for 4-6 months after infection

Source: modified from Molinari and Harte [6]

### **Transmission of the Disease:**

Hepatitis B is a bloodborne disease that is transmitted by percutaneous or permucosal exposure to blood or body fluids (including saliva ) of a person with either acute or chronic HBV infection. Persons infected with HBV can transmit the virus for as long as they are HBsAg-positive. Although, the degree of infectivity is best correlated with positive results for HBeAg. The risk of HBV infection is more a factor of exposure to blood than of exposure to general patient contact. However, HBsAg has been detected in 76% of salivary samples of known carriers.

The virus can be transmitted by a human bite and can be detected in nasopharyngeal secretions and gingival crevicular fluid. Blood contains the greatest proportion of HBV infectious particle titers of all body fluids and is the most critical vehicle of transmission in the health-care setting. HBsAg is also found in multiple other body fluids, including breast milk, bile, cerebrospinal fluid, feces, nasopharyngeal washings,

saliva, semen, sweat, and synovial fluid. However, the majority of body fluids are not efficient vehicles for transmission because they contain low quantities of infectious HBV, despite the presence of HBsAg. A millimeter of blood from an infected person may contain as many as 100 millions virus particles, meaning that only a small amount of blood is necessary to transmit the disease to others.

The potential for HBV transmission through contact with environmental surfaces has been demonstrated in investigations of HBV outbreaks among patients and HCP in hemodialysis units. Hepatitis B virus is capable of being transmitted by:

1. Parenteral route, through either:
  - a. Percutaneous contact (e.g. sharps injuries with contaminated instruments, or exposure of non intact skin to blood or body fluids of infected person); or
  - b. Permucosal contact (e.g. exposure of mucous membranes to blood, saliva, or other body fluids of a person with either acute or chronic HBV infection).

Examples of such routes include dental and surgical treatments, sexual activities, and frequent intimate contact which leads to contaminated fluids from one person contacting the mucous membranes or non-intact skin of another person, either directly or indirectly. In the dental operatory, parenteral transmission may occur from patient to DHCP, and less often from patient to patient, and from DHCP to patient.

2. Perinatal route:

When a pregnant woman is chronically infected with HBV, there can be as high as 80%-90% risk of infection for the newborn, of which 90% of those children become chronic HBV carrier with increased risk for having cirrhosis or hepatocellular carcinoma as they age.

In studies of HCP who sustained injuries from needles

contaminated with blood containing HBV, the risk of developing clinical hepatitis if the blood was positive for both HBsAg and HBeAg was 22 - 31%; the risk of developing serologic evidence of HBV infection was 37- 62%. By comparison, the risk of developing clinical hepatitis from a needle contaminated with HBsAg-positive, HBeAg-negative blood was 1- 6%, and the risk of developing serologic evidence of HBV infection, 23- 37%.

### ***Hepatitis B Virus Carrier State:***

A carrier is defined as a person who has HBsAg-positive results on at least two occasions at least 2 months apart or being HBsAg-positive and immunoglobulin M anti-HBc-negative at a single test. The HBV carrier is central in the epidemiology of HBV transmission. About 90% of those infected with HBV undergo complete recovery without developing a carrier state. About 2%-10% become carriers of the virus, with about one half eliminating the virus from their bodies within 5 years. The other half become chronic carriers and about 25% of these develop chronic active hepatitis with greater chance of developing liver cancer.

Anyone who has developed the disease, and some persons who have been exposed but have not been actively ill, may be carriers of HBV. The HBV carrier state develops more commonly via asymptomatic subclinical HBV infection versus acute infection. This means that even patients who appear to be healthy and have no history of the disease may be a source of infection. This presents a high risk for dental personnel because dental treatment brings them into contact with saliva and blood. Additionally, carriers with an asymptomatic subclinical infection are more likely to be HBeAg positive, indicating that they are in a more infectious, contagious state, and therefore are more liable to transmit the disease.

### ***High Risk Groups:***

- Health care providers.
- Patients in hemodialysis and hematology / oncology units.
- Clients and staff of institutions for developmentally disabled

persons.

- Newborns of hepatitis B carrier mothers.
- Intravenous drug abusers.
- Sexual partners of infected persons.

### *Risk in the Dental Operatory:*

Hepatitis B remains the most important occupationally acquired disease for dental professionals. Studies indicate that, for dentists, the risk for acquiring hepatitis B is three to six times that of the general population. That risk seems to be related to the frequency of contact with patient's blood.

The greatest dental occupational risk for exposure are the following:

- a. Injuries from contaminated sharps.
- b. Blood and saliva contamination of cuts and cracks on the skin or ungloved hands or hands with torn gloves.
- c. Spraying of blood and saliva onto open lesions of the skin or onto mucous membranes.

It has been shown that, for non-immune persons disease transmission from a needlestick exposure is up to 100 times more likely for exposure to hepatitis B e antigen (HBeAg)-positive blood than to HIV-positive blood. In hepatitis B there are over 100 million viral particles per mL of blood, whereas in AIDS there are only up to 100 viruses per mL of blood.

Although the potential for transmission of bloodborne infections from DHCP to patients is considered limited, precise risks have not been quantified by carefully designed epidemiologic studies. Transmission of HBV from dentist to patient has not been reported from 1987-2007, possibly reflecting such factors as:

- a. adoption of standard precautions,
- b. routine glove use,
- c. increased levels of immunity as a result of hepatitis B vaccination of DHCP,
- d. implementation of the 1991 OSHA bloodborne pathogen standard, and

e. incomplete ascertainment and reporting.

**Clinical Features:**

Hepatitis B virus infection may result in clinical symptoms in about one third of the cases and no symptoms or unrecognized symptoms in about two third of the cases. The clinical sign and symptoms in acute cases include combination of malaise, anorexia, nausea, vomiting, abdominal pain, jaundice, light colored stool, dark urine, and fever. Skin rashes, arthralgia, and arthritis also can occur. Jaundice, the sign most believed to be pathognomonic of hepatitis, is rarely evident.

**Diagnosis:**

Diagnosis of HBV is complicated by the variety of serological markers and the complex sequelae of the disease itself. Table 4 summarizes the significance of the serological markers HBV.

**Table 4**

*Interpretation of the Hepatitis B Serological Profiles*

Test	Result	Interpretation
HBsAg Anti-HBc Anti-HBs	Negative Negative Negative	- Susceptible
HBsAg Anti-HBc Anti-HBs	Negative Positive Positive	- Immune because of natural infection
HBsAg Anti-HBc Anti-HBs	Negative Negative Positive	- Immune because of hepatitis B vaccination
HBsAg Anti-HBc IgM Anti-HBc Anti-HBs	Positive Positive Positive Negative	- Acutely infected
HBsAg Anti-HBc IgM Anti-HBc Anti-HBs	Positive Positive Negative Negative	- Chronically infected

HBsAg Anti-HBc Anti-HBs	Negative Positive Negative	<ul style="list-style-type: none"> <li>- Recovering from acute infection, or</li> <li>- Immune and test is not sensitive enough to detect low level of Anti-HBs, or</li> <li>- Susceptible with false positive of Anti-HBc, or</li> <li>- Carrier and undetectable level of HBsAg present in the serum</li> </ul>
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Source: Molinari and Harte [6]

### ***Prophylaxis:***

Because no successful medical treatment exists to cure this disease, prevention is of paramount importance. Safe and effective vaccines for hepatitis B are available. Vaccination can protect both DHCP and patients from HBV infection and, whenever possible, should be completed when dentists or other DHCP are in training, before they come into contact with blood. The Saudi Arabian Ministry of Health requires serologic screening before immunization to identify positive cases and instruct them about preventive measures.

Because no vaccine is 100% effective, the CDC recommends that healthcare personnel who have contact with blood and are at risk for sharps injuries be tested for antibody response 1 to 2 months after the third dose of the vaccine series. Approximately half of nonresponders to the primary series will respond to a second 3-dose series. Nonresponders to vaccination who are HBsAg-negative should be considered susceptible to HBV infection.

Vaccine-induced antibodies decline gradually over time, and 60% of persons who initially respond to vaccination will lose detectable antibodies over 12 years. Even so, immunity continues to prevent clinical disease or detectable viral infection. Booster doses of vaccine and periodic serologic testing to monitor antibody concentrations after completion of the vaccine series are not necessary for vaccine responders.

### ***Control Measures:***

- Serologic screening before immunization is required to identify

positive cases and instruct them about preventive measures.

- All body fluids except sweat (e.g. Blood, saliva, gingival fluid and pus), from all dental patients should be considered infective.
- All sharp items (e.g., needles, scalers, burs, lab knives, and wires) that are contaminated with fluid or material, regardless of whether it is visible or not, are considered as potentially infective.
- standard precautions , engineering controls and work practices are established, and must be observed, to prevent injuries.
- The written, comprehensive program designed to minimize and manage DHCP exposures to blood and body fluids must be implemented.
- **Dental Health Care Personnel:**
  - All DHCP must follow the recommended standard precautions for all patients.
  - All DHCP will be screened for HBV (HBsAg).
  - Non-Saudi DHCP will be screened for HBV before recruitment and travelling to the Kingdom and again on arrival.
  - Only DHCP with negative HBsAg or positive HBsAg and positive Anti- HBs should be accepted to work in the Kingdom. (with the exception of those with rare qualifications, such as professors in universities and institutes of higher education).
  - If those tests shows intermediate results, PCR test should be performed.
  - HBsAg screening will also be repeated every two years for iqama renewal for non-Saudi DHCP.
  - Those with negative hepatitis B virus (HBsAg –ve) should receive hepatitis B vaccine series. For non-Saudi DHCP, the first dose of vaccine should be received before iqama application.
  - Vaccination is encouraged within 10 days of initial assign-



ment unless: 1) documentation exists that the DHCP has previously received the series; 2) antibody testing reveals that the DHCP is immune; or 3) medical evaluation shows that vaccination is contraindicated.

- Dental students and residents will be screened for HBV before starting the pre-clinical courses. They must have proof of immunity, either through previous exposure to vaccination (by demonstrating a titer level greater than ten international units (IU) of Anti-HBs), or by beginning the series of Hepatitis B vaccinations (for those with HBsAg –ve) before they may start patient treatment.
- All DHCP will be tested for anti-HBs 1-2 months after completion of the 3-dose vaccination series.
- DHCP who do not develop an adequate antibody response (i.e., anti-HBs <10 mIU/mL) to the primary vaccine series should complete a second 3-dose vaccine series or be evaluated to determine if they are HBsAg-positive.
- Another test for anti-HBs at the completion of the second vaccine series should be done and if no response to the second 3-dose series occurs, non-responders should be tested for HBsAg.
- Non-responders to vaccination who are HBsAg-negative should be considered susceptible to HBV infection and should be counseled regarding precautions to prevent HBV infection and the need to obtain HB immunoglobulin prophylaxis for any known or probable parenteral exposure to HBsAg-positive blood.
- Persons who prove to be HBsAg-positive should be counseled regarding how to prevent HBV transmission to others and regarding the need for medical evaluation.
- According to MOH regulations, DHCP with viral load more than 100,000 copy/ml should be restricted from performing exposure prone invasive procedures (see section on Work Restrictions).

## ***Management of Exposures to HBV:***

### **1. Treatment of the exposure site.**

- a. Bleeding of the site should be encouraged.
- b. The site should be washed with plenty of water.
- c. Exposure site should be disinfected.
- d. Dressing should be placed on exposure site.

### **2. Making an exposure report.**

- a. An incidence form should be filled and sent to the Infection Control Officer for further management, and a copy of the form should be kept in the Infection Control Office (see Policies and Procedures Manual).
- b. The source individual should be identified and documented. Arrangements should be done to have the source individual tested as soon as possible to determine HIV, HCV, and HBV infectivity.
- c. If the source individual is already known to be HIV, HCV and/or HBV positive, new testing need not be performed.
- d. The following details of the occupational exposure should be documented for every incident, and the incidence report kept within the confidential medical records of the DHCP in the Infection Control Office (for at least the duration of employment plus 30 years) and provided to the necessary qualified health-care professional:
  - i. Date and time of exposure.
  - ii. The routes of exposure (e.g., percutaneous injury, mucous membrane, or non-intact skin exposure, or bites resulting in blood exposure to either person involved).
  - iii. Details of the exposure, including its severity and the type and amount of fluid or material. For a percutaneous injury, severity might be measured by the depth of the wound, gauge of the needle, and whether fluid was injected; for a skin or mucous membrane expo-

- sure, the estimated volume of material, duration of contact, and the condition of the skin (e.g., chapped, abraded, or intact).
- iv. Details of the procedure being performed when the incident occurred.
  - v. Type and brand of the device involved (syringe, suture needle).
  - vi. Location of the incident (clinic, operation room, patient room, etc.)
  - vii. Explanation of how the incident occurred.
  - viii. Details regarding whether the source material was known to contain bloodborne pathogens (HBV, HCV or HIV). And, if the source was infected, the stage of disease, history of therapy, and viral load, if known.
  - ix. Details regarding the exposed person (e.g., hepatitis B vaccination and vaccine-response status).
  - x. Engineering controls in use at the time.
  - xi. Work practices followed.
  - xii. Protective equipment or clothing that was used at the time of the exposure incident (gloves, eye shields, etc.).
  - xiii. The affected DHCP's training.
  - xiv. Details regarding counseling, post-exposure management, and follow-up.
- e. This information should be also be recorded in sharps injury log and reviewed as part of the annual infection control program evaluation and maintained for at least five years.

### **3. Evaluation of the exposure source.**

The patient should be asked to have his/her blood drawn for testing for HBV or other infectious diseases unless the patient's serostatus is already known. The source individual's blood shall be tested as soon as feasible and consent is obtained in order to screen for hepatitis B markers and determine HBV infectiv-

ity.

**a. If the source is HBsAg positive:**

- i. If DHCP is unvaccinated: Passive immunization with Hepatitis B Immunoglobulin (HBIg: 0.06 ml/kg intramuscularly) should be instituted within 48 hours (its effectiveness is unknown if given later than 7 days after exposure). This should be followed by a complete course of the hepatitis B vaccine, the first dose of which may administered immediately or within 7 days of the accident.
- ii. If DHCP is vaccinated: determine if he/she is a good responder or non-responder.
- iii. If DHCP is a good responder (anti-HBs level is >10IU/ml), no treatment is necessary.
- iv. If DHCP is a non-responder (anti-HBs level is <10 IU/ml), HBIg is given as soon as possible preferably within 24 hours (but not later than 7 days) after exposure and hepatitis B vaccine series started at the same time.
- v. If DHCP refused to be revaccinated, a second dose of HBIg should be given one month later.

**b. If the source HBsAg status is unknown:**

- i. The DHCP should be managed as if the source is positive.
- ii. If DHCP's antibody response status is unknown: the DHCP should be screened for anti- HBs and managed as a non-responder until the laboratory screening results are available.

**c. If the source is negative for HBsAg:**

- i. Check the DHCP immune status.
- ii. If immune against HBV, no further management is necessary.
- iii. If non-immune, the DHCP should be advised to receive hepatitis B vaccine series.

- iv. If not vaccinated, the DHCP should be advised to receive hepatitis B vaccine series.

#### **4. Evaluating the DHCP**

- a. The DHCP shall be screened for hepatitis B markers.
- b. The DHCP should be followed-up to determine if they have received the 3 doses of hepatitis B vaccine.
  - i. If the DHCP has not been vaccinated or has not completed the 3 doses, they should be advised to complete the vaccine series (0,1,6).
  - ii. If DHCP received 3 doses of Hepatitis B vaccine and he /she does not know their immune status, advise to check anti-HBs level.

### ***Hepatitis C***

**[6, 10, 13, 25, 28, 32-35, 37-42]**

Hepatitis C is a bloodborne disease that is caused by Hepatitis C virus (HCV). The virus is a single stranded RNA virus which has 6 genotypes and more than 90 subtypes. Hepatitis C was previously termed parenterally transmitted non-A, non-B (NANB) hepatitis.

#### ***Epidemiology:***

Prevalence of hepatitis C in Saudi Arabia among blood donors is 1.5%, and the overall prevalence of hepatitis C among hemodialysis patients in different centers is 68% (range 16-94%).

In the past 15 years, studies have shown reductions in the prevalence of hepatitis C in Saudi Arabia. The prevalence rates in Saudi Arabia have been reported to be between 0.4%- 3.88 %, the results varied according to age, and nationality of the subjects, as well as region of residence. Drug users, however, had a much higher prevalence of HCV, 37.7%, compared to the general population.

Patients attending a hospital in Jizan region (for any reason) had among the highest prevalence rates (3.8 %) by region. Foreign nationals had a higher prevalence rates than Saudis (1.6-3.3 % vs. 0.2- 0.98 % respectively) . Egyptian nationals have been reported with the highest prevalence (8.1-14.6 %) followed by Pakistanis (3.6- 3.8 %). Preva-

lence among foreign nationals was reportedly lower than in their respective countries, probably due to mandatory screening of all expatriates.

Prevalence rates of anti-HCV tend to increase with increasing age. Children younger than 15 years of age were reported to have a lower prevalence rate compared to adults, 0.012 vs. 0.202%, respectively.

The overall prevalence in hemodialysis patients was reported as 72.6 %, with the rate increasing with the number of years the patient has been on dialysis. A prevalence rate of 16.4 % has been reported for patients on dialysis for one year and 94.5 % for patients on dialysis for 3 years or more.

### ***Characteristic Features of the Causative Microorganism:***

The incubation period of Hepatitis C is 30-150 days. The HCV RNA can be detected in the blood as soon as 1 week after initial exposure and antibodies to HCV can be detected within 3 months after onset of infection.

The virus is different from other hepatitis viruses in that it has the ability to mutate and modify viral surface components, which is a major factor in the very high rate of chronic HCV infection.

### ***Transmission of the Disease:***

The primary route of transmission of HCV is via the blood. However, in recent years, less than 5% of the reported cases have been related to blood transfusions. It is most efficiently transmitted via percutaneous exposure (through skin) to blood by the sharing of contaminated needles among injection drug users. This illegal intravenous drug use accounts for the majority (60%) of reported cases of acute HCV infections.

Perinatal and familial transmissions have also been documented. However, the lower number of HCV infections reported in children compared with those reported in adults suggested that perinatal and childhood transmission was not a major mode of infection and that other modes of transmission, such as unscreened blood transfusion before 1990 and intravenous drug use, were likely to be the main modes of infection. In contrast to HBV transmission, sexual transmission of HCV appears less efficient.

The risk of HCV infection is more a factor of exposure to blood than of exposure to general patient contact. However, HCV RNA is found in the saliva of approximately 50% of patient with chronic HCV, but the rate of transmission through saliva is low.

### ***Hepatitis C Virus Carrier State:***

The carrier rate associated with HCV is higher than that associated with HBV. An estimated 75%-85% of those infected with HCV become chronic carriers. Chronic hepatitis C can take as long as 20 years to develop, and may progress without signs or symptoms. An estimated 20% of chronic carriers develop chronic liver disease such as cirrhosis and liver cancer. Death from cirrhosis may occur in 1%-5% of those infected.

### ***High Risk Groups:***

- Intravenous drug abusers.
- Recipients of clotting factors.
- Patients on hemodialysis
- Recipients of blood or solid organs
- Newborns of hepatitis C carrier mothers.
- Health care providers.
- Sexual partners of infected persons.

### ***Risk in the Dental Operatory:***

Health care personnel are at risk for exposure to patient blood and possible subsequent infection from bloodborne diseases including HCV. However, HCV does not appear to be transmitted efficiently through occupational exposures to blood. The majority of studies indicate the prevalence of HCV infection among dentists, surgeons and hospital based HCP has declined and is currently similar to that among the general population, approximately 1% to 2%.

A history of unintentional needle-sticks was the only occupational risk factor independently associated with HCV infection. Follow-up studies of HCP exposed to HCV-infected blood through percutaneous or other sharps injuries have determined a low incidence of seroconversion (mean: 1.8%; range, 0%--7%). One study determined trans-

mission occurred from hollow-bore needles but not other sharps.

At least two cases of HCV transmission from a blood splash to the conjunctiva and one case of simultaneous transmission of HCV and HIV after non-intact skin exposure have been reported.

No studies of transmission from HCV-infected DHCP to patients have been reported, and the risk for such transmission appears limited. Multiple reports have been published describing transmission from HCV-infected surgeons, which apparently occurred during performance of invasive procedures; the overall risk for infection averaged 0.17% .

### ***Clinical Features:***

Since hepatitis C virus infection often induces less hepatic inflammatory reactions than the HBV, most (60%-70%) individuals with acute HCV infection are asymptomatic or have non-specific symptoms. More than 85% of hepatitis C cases progress to chronic HCV infection. Chronic HCV can take as long as 20 years to develop and progresses without sign and symptoms until the liver disease has progressed to the advanced stages. Almost 80% of chronic cases are stable with mild to moderate histological disease. The other 20% eventually develop to cirrhosis or liver cancer.

### ***Diagnosis:***

HCV can be diagnosed by blood testing for antibodies to HCV. The polymerase chain reaction (PCR) test is an advanced RNA technology test used to detect ribonucleic acid from the virus, and may be an indicator of the transmission potential of the virus. A positive antibody and negative PCR test may indicate a previously cleared infection. Patients who are antibody positive but PCR negative should have a second PCR test after 4-6 weeks to confirm their negative status.

### ***Prophylaxis:***

There is no vaccine against hepatitis C. However, effective treatments are available to control the effect of the disease.

### ***Control Measures:***

- All body fluids except sweat (e.g. blood, saliva, gingival fluid and



- pus), from all dental patients should be considered infective.
- All sharp items (e.g., needles, scalers, burs, lab knives, and wires) that are contaminated with fluid or material, regardless of whether it is visible or not, are considered as potentially infective.
  - standard precautions, engineering controls and work practices are established, and must be observed, to prevent injuries.
  - The written, comprehensive program designed to minimize and manage DHCP exposures to blood and body fluids must be implemented.
  - **Dental Health Care Personnel:**
    - All DHCP should follow the recommended standard precautions for all patients.
    - All DHCP will be screened for HCV (Anti-HCV).
    - Non-Saudi DHCP will be screened for Anti-HCV before recruitment and travelling to the Kingdom and again on arrival.
    - Only DHCP with negative Anti-HCV should be accepted to work in the Kingdom (with the exception of those with rare qualifications, such as professors in universities and institutes of higher education).
    - If Anti-HCV test shows intermediate results, PCR test should be performed.
    - Anti-HCV screening will also be repeated every two years for iqama renewal for non-Saudi DHCP.
    - Dental student and residents will be screened for HCV before starting the preclinical courses.
    - Persons who prove to be HCV positive should be counseled regarding how to prevent HCV transmission to others and regarding the need for medical evaluation.
    - DHCP who prove to be HCV positive should not perform exposure-prone invasive procedures (see Work Restrictions).

## **Management of Exposures to HCV:**

1. Treatment of exposure site (as in Hepatitis B)
2. Making an exposure report (as in Hepatitis B)
3. Evaluation of the exposure source

The source individual's blood shall be tested for anti-HCV.

- a. If the source is negative for hepatitis C, no further management will be done.
  - b. If the source is positive for hepatitis C, early diagnosis of HCV infection for DHCP is important.
    - i. The DHCP should be tested for HCV PCR after 2-8 weeks.
    - ii. Follow-up testing (e.g. 4-6 months) for anti-HCV and ALT activity (alanine aminotransferase blood test, typically used to detect liver injury).
    - iii. If HCV infection is identified, a short course of interferon is initiated.
    - iv. Immunoglobulin is not recommended for post-exposure prophylaxis (PEP) after exposure to HCV positive blood.
4. Evaluating the DHCP  
The DHCP shall be screened for anti- HCV and liver function tests (LFTs).

### ***Delta Hepatitis***

**[4, 6, 10, 13, 43]**

Hepatitis delta virus (HDV) is a defective bloodborne virus requiring the presence of HBV to replicate. Patients co-infected with HBV and HDV have substantially higher mortality rates than those infected with HBV alone. An estimated 4% of persons with acute HBV infection are also infected with HDV.

### ***Epidemiology:***

Delta hepatitis is worldwide in distribution. It is endemic in Mediterranean countries such as southern Italy, the Middle East and parts of

Africa, as it is in parts of South America.

In 2004, the prevalence rate in hospital- and clinic-based HBsAg positive patients in Saudi Arabia was reported as 8.6%. In healthy blood donors who were HBsAg positive the rate was 3.3%, and in healthy blood donors was 0.06%.

***Characteristic Features of the Causative Microorganism:***

Delta hepatitis is unique and distinct from HBV. However, HDV depends on HBV for clinical expression. HDV requires HBV as a helper virus for an outer protein coat (HBsAg) and thus for replication.

***Transmission of the Disease:***

Transmission is similar to that of HBV (i.e., percutaneous or permucosal). The HDV can be transmitted by blood or blood products, and sexual contact, as long as HBsAg is found in the patient's blood. Frequent percutaneous exposures (such as those occurring with intravenous drug users and hemophiliacs) are considered as high risk factors. Non-percutaneous transmission of HDV is believed to occur primarily by intimate contact and transmucosal exchange of body fluids.

***High Risk Groups:***

Similar to that of HBV.

***Clinical Features:***

Hepatitis relating to delta infection occurs in two primary modes. The first mode is simultaneous infection with HBV and HDV. When simultaneous infection occurs, the acute clinical course of hepatitis often is limited, with resolution of both HBV and delta infections, although fulminant hepatitis may develop.

The second mode involves acute delta super-infection in HBsAg carriers. These patients are more likely to have a serious and possible acute fulminant form of hepatitis that more often leads to chronic HDV infection.

***Prophylaxis:***

Dental health care personnel who are immune to HBV following hepatitis B vaccinations or who have developed natural active immu-

nity against HBV following viral infection are also protected against clinical exposure to HDV infection. Vaccination against HBV will also prevent infection with HDV.

### ***Control Measures and Management of Exposures to HDV:***

- The same control and preventive measures as for HBV infection are indicated.
- HBV carriers should take extreme care in avoiding exposure to HDV as no currently immunobiologic product exists for prevention of HDV super-infection.
- Immunization to prevent HBV infection, through either pre- or post-exposure prophylaxis, can also prevent HDV infection.

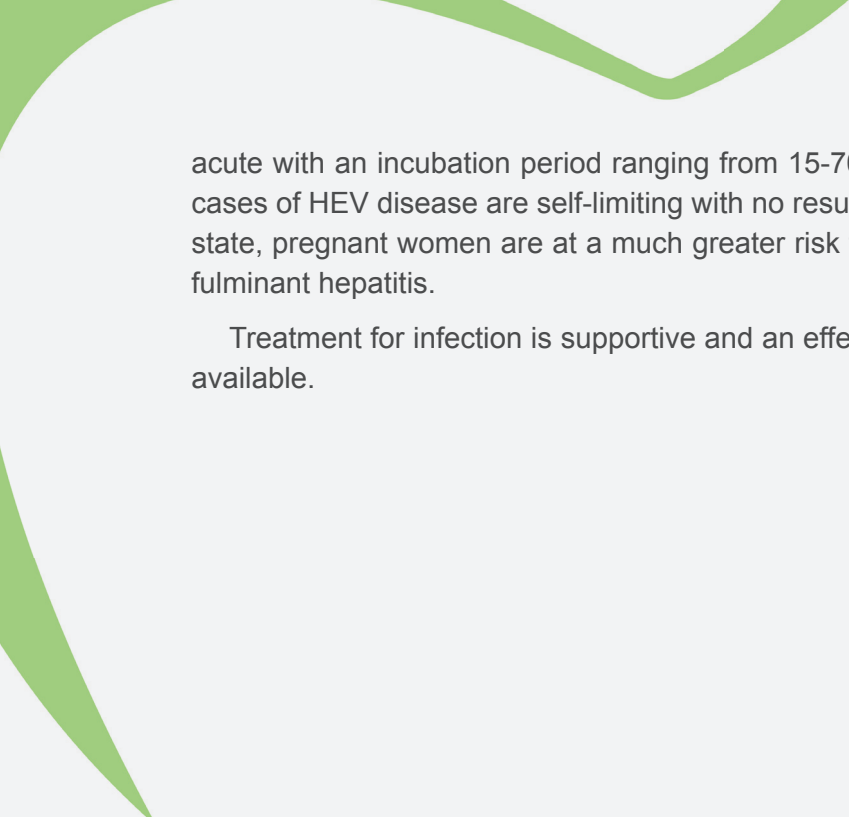
### ***Hepatitis E Virus [4, 6, 24, 44]***

Hepatitis E, which is not bloodborne, is most frequently transmitted via fecal/oral routes through contaminated food or water. The disease occurs most frequently in the form of an epidemic in developing countries. Transmission risks have been found for people who live or travel to an endemic area; with the greatest risks being for those individuals having close personal contact with HEV infected persons, and those who consume contaminated food or water.

Most outbreaks have occurred in India, Asia, portions of Africa, and Mexico and none have been reported in Europe, the United States, and Australia. In Saudi Arabia, studies published within the past 15 years reported the prevalence of anti- HEV to range between 8.37 - 33.3 %, with non-Saudi nationals having double the rate of Saudis. The rate was found to increase with age , and there was a significant association between anti-HCV and anti-HEV. Donors positive to anti-HCV were five times more likely to be positive for anti-HEV.

Transmission of HEV is not a major concern in a standard dental setting; HEV is not considered a routine occupational infection for healthcare providers in particular because parenteral transmissions are at most very rare occurrences.

When viral infection is followed by symptomatic disease, onset is

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acute with an incubation period ranging from 15-70 days. While most cases of HEV disease are self-limiting with no resultant chronic carrier state, pregnant women are at a much greater risk for developing fatal fulminant hepatitis.

Treatment for infection is supportive and an effective vaccine is not available.

## Human Immunodeficiency Virus

**[4-5, 7, 10, 13, 21, 28, 31-35, 45-48]**

Infection by human immunodeficiency virus (HIV) is extremely serious. Even the best informed and conscientious practitioners are challenged by the fact that hepatitis B and acquired immune deficiency syndrome (AIDS), caused by HIV, follow very long incubation periods and most infected individuals are not identifiable.

### *Epidemiology:*

The UNAIDS 2010 report estimates the worldwide HIV prevalence to be between 0.7 - 0.8 %, with the highest prevalence being in the sub-Saharan Africa and the Caribbean region (5.0 % and 1.0 %, respectively). It is estimated that more than 45 million persons worldwide are infected with HIV. Since the first reports of AIDS in 1981, more than 25 million people have died of the disease. In 2007 there were about 2.5 million deaths that were directly attributable to AIDS. More than 96% of the cases are in low and middle income countries. Women account for almost 50% of cases and 40% are among young people.

Sixty-eight percent of all people living with HIV live in sub-Saharan Africa. This region alone suffered 76% of all AIDS deaths in 2007. Asia also bears a very large burden of HIV/AIDS with an estimated 4.9 million people living with HIV infection in 2007. However, the annual number of new HIV infections globally has been steadily declining since the late 1990s. The decline in AIDS cases may correspond to the introduction of highly active antiretroviral therapy (HAART) and protease inhibitors (PI) to the antiretroviral therapy (ART) regimens.

Several countries and regions, however, are showing increasing incidences of new HIV infections. The Middle East and North Africa are estimated to have an increasing incidence of HIV infections, with a prevalence rate of 0.2 %. During the last few years, Saudi Arabia also has had a significant increase in the reported annual new HIV-positive cases, and hence total number of cases. Studies published within the past 11 years have reported a prevalence of seropositivity for HIV among blood donors in Saudi Arabia to range between 0- 0.2 %.

An estimated 67- 76 % of affected persons in Saudi Arabia are male expatriates. The HIV prevalence in Saudi nationals has been calculated as 0.02% .

Most people infected with HIV are asymptomatic and are unaware that they are HIV-positive. Regardless of the stage of disease, however, all HIV -infected persons are potentially infectious. Once HIV infects a host, that person remains infected for the rest of his or her life.

### ***Characteristic Features of the Causative Microorganism:***

HIV is a ribonucleic acid (RNA) virus and is classified as a retrovirus. Retroviruses are unique because they contain the enzyme reverse transcriptase. This enzyme is essential in performing a retrograde step, converting viral RNA into an intermediary DNA to reproduce new, infectious virions.

The uniqueness of HIV infection is based upon the fact that HIV attacks cells of the immune system primarily, specifically lymphocytes (CD41) and macrophages. As the infection progresses, HIV slowly damages the immune system and weakens the defenses of the body against other diseases such as tuberculosis, hepatitis, cancer, and opportunistic diseases.

When the HIV-positive individual becomes symptomatic (has clinically defined symptoms), he/she will be classified as having AIDS. AIDS is a term given to a group of disorders characterized by a profound cell-mediated immunodeficiency consequential to irreversible suppression of T lymphocyte by the HIV. It is the clinical endpoint of the HIV infection and is essentially a 100% lethal infection.

The incubation period from the time of infection to the development of signs and symptoms of AIDS is long; the present mean time is approximately 11 years. Thus, many years are available for HIV-infected individuals to spread the virus to partners who share drug-abuse habits and/or sex. Additionally, this “reservoir” of time creates prolonged periods during which medical and dental care must be provided for these HIV-positive individuals.

Current knowledge continues to show that this retrovirus does not

survive well in the environment, is unable to replicate outside of the body, and is rapidly inactivated. Thus, the possibility of environmental transmission is considered remote.

Studies have shown that HIV is inactivated rapidly after being exposed to commonly used chemical germicides at concentrations that are much lower than used in practice. In addition to commercially available chemical germicides, a solution of sodium hypochlorite (household bleach; Clorox) prepared daily is an inexpensive and effective germicide. Concentrations ranging from approximately 500 ppm sodium hypochlorite (1:100 dilution of household bleach) to 5,000 ppm (1:10 dilution of household bleach) are effective depending on the amount of organic material (e.g. blood, mucous) present on the surface to be cleaned and disinfected.

### ***Transmission of the Disease:***

The HIV is not a virulent virus. It is bloodborne, and there is no scientific evidence to suggest or support possible HIV transmission by casual contact, air, water, insects, or animal bites. It is transmitted most easily through blood, semen, and vaginal secretions during sexual intercourse. Sexual contact accounts for the majority of cases in adults. Mucosal linings of the vagina, penis, rectum, or the oral cavity are lined with immune system cells (dendritic cells) and present receptors on which HIV can bind. These cells then migrate to the regional lymph nodes, initiating HIV infection.

HIV is also transmitted through exposure to shared needles (for drug use), through tattoo needles, accidental exposure to blood that occurs in occupational settings, organ donation, transfusion of contaminated blood or blood products, and by infected mother to her child during birth or through breast-feeding. The transmission of HIV itself is a concern, but not a major threat, in the dental setting. However, patients who are HIV positive often have other diseases that can be transmitted more easily through dental treatment, particularly tuberculosis and hepatitis B.

When careful personal barrier techniques (gloves being the most important) and appropriate disinfection and sterilization principles are



followed, practitioners, staff, and patients should feel safe from contracting the disease. Prospective studies worldwide indicate the average risk of HIV infection after a single percutaneous exposure to HIV-infected blood is 0.3% (range: 0.2- 0.5%). After an exposure of mucous membranes in the eye, nose, or mouth, the risk is approximately 0.1%. The precise risk of transmission after skin exposure remains unknown but is believed to be even smaller than that for mucous membrane exposure.

Several factors may increase the risk of transmission:

- If HCP is exposed to a large quantity of blood.
- A procedure that involved a needle which is placed directly in a vein or artery or a deep injury.
- If the source patient is in the terminal illness (possibly reflecting the higher titer of HIV in late-stage AIDS).
- If the injury is deep with hollow-bore needles or penetrating sharps related event. Laboratory studies have determined that if needles that pass through latex gloves are solid rather than hollow-bore, or are of small gauge (e.g., anesthetic needles commonly used in dentistry), they transfer less blood.

### ***High Risk Groups:***

- Sexual partners of an infected person.
- Intravenous drug abusers.
- Patients exposed to blood/blood products through transfusion or infusion, or through organ transplantation.
- Patients on hemodialysis.
- Newborns of infected mothers.
- Children breast feeding from infected mother.
- Health care providers.

### ***Risk in the Dental Operatory:***

HIV-infected persons are being treated in dental offices; and many times, both the dental professional and the patient are unaware of the infections. Clinical and scientific evidence supports the belief that the risk of HIV transmission after percutaneous exposure of HCP to HIV-

infected blood is quite low. The reported incidence of infection following needle stick or cut with item contaminated with HIV-infected blood or serum is 0 to 0.5 percent. In the United States, only two dental professionals have been known to seroconvert from possible occupational infection; both of these professionals were dentists. As of December 2002, CDC had confirmed 57 cases of American HCP (none were DHCP) with documented HIV seroconversion resulting from accidental occupational exposures. Routes of exposure in these cases included percutaneous (puncture / cut injury) exposure (48 cases), mucocutaneous exposure, and unknown.

Transmission of HIV to six patients of a single dentist with AIDS has been reported, but the mode of transmission could not be determined.

### ***Clinical Features:***

Because of oral signs and symptoms of HIV infection, dental professionals may be the first to either refer or make the diagnosis of HIV infection and/or AIDS. Common oral findings caused by HIV may include:

1. **Candidiasis.**  
This may be the first sign or symptom of HIV infection. Intraoral infection is frequently accompanied by angular cheilitis.
2. **Hairy leukoplakia (HL).**  
A common manifestation of AIDS, HL appears as corrugated white lesions, nearly always occurring on the lateral borders of the tongue.
3. **Periodontal disease.**  
Progressive and premature periodontal disease is a relatively frequent finding in HIV-infected individuals. HIV-associated periodontal disease is often rapidly progressive and painful.  
Other relatively common oral findings include:
4. **Warts associated with human papilloma virus types.**
5. **Herpetic infections, which appear to be related to factors**

permitting more frequent and severe activation of herpes simplex virus.

6. Recurrent aphthae.
7. Autoimmune xerostomia.

### ***Diagnosis:***

History and clinical criteria are of the essence in the provisional diagnosis of HIV infection but laboratory investigations are required for confirmation of the disease. A blood test can be used to determine the presence of antibodies to HIV before symptoms appear. A negative test, also known as a seronegative result, means that no infection was present at the time of the test. However, negative result does not rule out the possibility of HIV infection, because there is a 'window' period between acquisition of infection and the development of antibodies, and most people develop detectable antibodies within 6 months of infection. The test should be repeated few months later.

More recent technical improvements in testing have resulted to the ability to quantify the viral load in the blood. The use of PCR test (polymerase chain reaction test that is used to detect ribonucleic acid from the HIV virus) and viral load testing have improved the possibility of diagnosing early HIV infection, predicting the probability of transmission, predicting the progression in the chronically infected and assessing the need for antiviral therapy.

### ***Prophylaxis and Treatment:***

The HIV has a characteristic of mutating, increasing the difficulty of development of effective drugs and vaccines for the virus. Because there is no effective vaccine, education and behavioral change are the main methods of controlling the spread of the disease.

Animal studies have found that post-exposure prophylaxis (PEP) prevented retroviral infection or decreased its rate in some cases; efficacy was lower with delayed time to treatment, shorter duration of therapy, or decreased dose. It is largely unknown, however, how much these animal studies can be extrapolated to humans. In a retrospective case-control study among HCP, PEP was associated with an 81%

decrease in the risk of HIV seroconversion after percutaneous exposure to HIV-infected blood. Failure of PEP to prevent HIV infection in HCP has been reported in at least 21 instances. Possible factors have included exposure to a resistant strain, high titer of large inoculum, delayed initiation or short duration of the regimen, and host factors such as diminished cellular immune response.

Currently, two or three drugs are recommended for PEP regimens. Zidovudine (ZDV) and Lamiduvine (3TC) for 4 weeks is the recommended regimen. If the risk of transmission is high, a third drug, notably protease inhibitor, for instance Indinavir, can be added to the regimen, over the four week course of treatment.

In the event of contraction of the disease, there are medical therapies that may delay its progression; however, there is no cure. The current standard of care is using primary and secondary chemoprophylaxis for the prevention of opportunistic infections (OI), which continue to be frequent causes of death in people infected with HIV. Maintaining a CD4 cell count above 200 is considered a primary strategy in prevention of OIs. Controlled clinical trials have shown the use of HAART to inhibit HIV replication, suppress the viral load, sustain this suppression, significantly improve immune function, markedly reduce morbidity and mortality of HIV/AIDS, reduce the incidence of OI, and reduce deaths by 60% to 80%.

### ***Control Measures:***

- All body fluids except sweat (e.g. blood, saliva, gingival fluid and pus), from all dental patients should be considered infective.
- All sharp items (e.g., needles, scalers, burs, lab knives, and wires) that are contaminated with fluid or material, regardless of whether it is visible or not, are considered as potentially infective.
- Standard precautions, engineering controls and work practices are established, and must be observed, to prevent injuries.
- The written, comprehensive program designed to minimize and manage DHCP exposures to blood and body fluids must be implemented.

- **Dental Health Care Personnel:**

- All DHCP must follow the recommended standard precautions for all patients.
- All DHCP will be screened for HIV before recruitment. Non-Saudi DHCP will be screened for HIV before recruitment and travelling to the Kingdom and again on arrival. HIV screening is done every two years for iqama renewal for DHCP coming from Ethiopia, Eritrea, Kenya, Somalia, Djibouti, Thailand, Nigeria, Sudan, Nepal, and Vietnam..
- Any DHCP who become HIV positive should notify the employer immediately so a decision can be made regarding whether this individual will continue to provide patient care. Decisions are made on the basis of a case-by-case evaluation of the circumstances.
- Any DHCP who is HIV positive should not perform exposure-prone invasive procedures (see Work Restrictions).

### ***Management of Exposures to HIV:***

Management of the health-care worker who has had a parenteral (e.g., needle stick or cut) or mucous membrane (e.g., spatter to the eye or mouth) exposure to blood or bloody secretions from an HIV positive patient should include the following:

1. Hands, mucous membrane and other skin surfaces that are contaminated with blood or bloody fluids or secretions should be washed immediately and thoroughly. A skin puncture should be encouraged to bleed and the wound should then be washed thoroughly.
2. An incident report should be written including information of the location and medical file number of the source (patient) and health care worker.
3. Confirmation that the source patient is HIV positive should be made.
4. Dental health care personnel should be evaluated serologi-

cally for HIV antibody as soon as possible after the exposure to establish serostatus before exposure. If DHCP is seronegative, he/she should be tested at six weeks, and again at three, six, and 12 months following exposure to determine whether transmission has occurred. Most exposed persons who have been infected will seroconvert during the first 12 weeks after exposure.

5. No further follow-up of DHCP as described above is necessary if the source patient is seronegative, unless the source patient is at high risk of HIV infection.
6. Because most occupational exposures to HIV do not result in transmission, the decision to recommend PEP must balance the risk of infection (represented by details of the exposure itself and information about the exposure source) with the efficacy and adverse side effects of PEP.
7. If a decision is made to use post-exposure prophylaxis, it should be initiated as soon as possible preferably within 24-36 hours (Table 5).

**Table 5**

Recommended HIV Postexposure Prophylaxis for Percutaneous Injuries:

Exposure type	Infection status of source				
	HIV positive class 1 <sup>a</sup>	HIV positive class 2 <sup>a</sup>	Source has unknown HIV status <sup>b</sup>	Unknown source <sup>c</sup>	HIV negative
Less severe <sup>d</sup>	Recommend basic 2-drug PEP	Recommend expanded 3-drug PEP	Generally, no PEP warranted, but consider basic 2-drug PEP <sup>e</sup> for source with HIV risk factors <sup>f</sup>	Generally, no PEP warranted, but consider basic 2-drug PEP <sup>e</sup> in settings where exposure in HIV-infected persons is likely	No PEP warranted
More severe <sup>g</sup>	Recommend expanded 3-drug PEP	Recommend expanded 3-drug PEP	Generally, no PEP warranted, but consider basic 2-drug PEP <sup>e</sup> for source with HIV risk factor <sup>f</sup>	Generally, no PEP warranted, but consider basic 2-drug PEP <sup>e</sup> in settings where exposure to HIV infected persons is likely	No PEP warranted

<sup>a</sup> HIV positive, class 1 – asymptomatic HIV infection or known low viral load (<1,500 RNA copies/mL) HIV positive, class 2 –symptomatic HIV infection.

<sup>b</sup> Source of unknown HIV status (e.g. deceased source person with no samples available for HIV testing)

<sup>c</sup> Unknown source (e.g. a needle for a sharps disposal container)

<sup>d</sup> Less severe (e.g. a solid needle and superficial injury)

<sup>e</sup> “Consider PEP” indicates that PEP is optional and should be based on an individualized decision by the exposed person in consultation with the treating clinician.

<sup>f</sup> If PEP is taken and the source is less determined to be HIV negative, PEP should be discontinued.

<sup>g</sup> More severe (e.g. large-bore hollow needle, deep puncture, visible blood on device, or needle used in patient’s artery or vein).

Source: Cleveland and Cardo [28]

## **Respiratory Infections**

Respiratory infections are the most common microbial disease found in humans. Diseases resulting from acute respiratory illness such as influenza, tuberculosis and pneumonia, are responsible for over 10% of the global deaths following microbial infection. Etiologies of respiratory infections are quite varied, as numerous viruses, bacteria, fungi, and parasitic microbes are involved. [6]

### **General Features of Microbial Respiratory Infections [6]**

#### ***Bacterial Infections***

Noninvasive bacterial infections lead to inflammation of the site of the local infection. More severe invasive diseases are associated with fever and white cell infiltration. Syndromes range from localized infections to aggressive pneumonias. Examples of bacterial respiratory infections include tuberculosis, pneumococcal pneumonia, legionellosis, tularemia, plague, anthrax. Most can be effectively treated with appropriately administered antibiotics.

#### ***Viral Infections***

Viral respiratory infections are the leading cause of human disease, hospitalization, and mortality. Syndromes range in severity from mild colds to acute and chronic pneumonias, and most cannot be treated with antimicrobial chemotherapy. These infections are the leading cause of inappropriate antibiotic use.

#### ***Mycotic and Parasitic Infections***

Many mycotic and parasitic infections are associated with chronic infection and pneumonias. Increased susceptibility to such diseases are found with immune compromised persons.



## Upper Respiratory Tract Infections

It is conventional to divide the respiratory tract into two parts; upper and lower. The upper respiratory tract is comprised of the nasal cavity, nasopharynx, and larynx. The trachea, bronchi, and lungs constitute the lower respiratory tract.

Infections of the upper respiratory tract are more common than any other microbial disease. Many infections are self-limiting but can lead to more serious secondary sequelae in certain susceptible individuals. Many of the microorganisms responsible for upper respiratory tract infections have been isolated in dental aerosols. Dental students have been shown to experience a consistently higher incidence of upper respiratory tract infections than their counterparts in medical and pharmacy schools. A positive correlation also has been demonstrated between the incidence of common cold epidemics in patients and in DHCP who treated them. [6]

### **Common Cold [6, 12-13]**

#### ***Causative Microorganism:***

Several viruses can cause the common cold, but rhinoviruses are by far the most common. Rhinoviruses are RNA viruses that have an incubation period of 1 to 4 days leading to onset of acute symptoms.

#### ***Transmission of the Disease:***

Actual shedding of the virus usually precedes the onset of clinical symptoms by 1 to 2 days, but peak viral secretion occurs during the symptomatic phase. Rhinoviruses are spread by aerosols and direct person to person contact via contaminated hands. Viruses from infected people are airborne in droplet nuclei that are emitted during respiration, talking, sneezing, and coughing. These viruses are also able to remain viable on skin and environmental surfaces for hours.

#### ***High Risk Groups:***

Predisposing factors for susceptibility include physical and emotional stress, and allergic nasopharyngeal disorders.

### ***Clinical Features:***

Signs and symptoms include profuse nasal discharge, sneezing, headache, fever malaise, dryness, soreness, hoarseness, and tickling of the throat. Nasal secretions during the symptomatic period are clear or mucoid in appearance. As the illness progresses a cough may appear as an increasingly prominent symptom lasting up to 2 weeks. Smell and taste are frequently impaired.

In the absence of complications, signs and symptoms resolve in 4 to 10 days. Secondary bacterial infections are frequent and consist of suppuration in the nasopharynx with involvement by direct extension from the nose to the paranasal sinuses, ears, mastoids, pharynx, larynx, trachea, bronchi and lungs.

### ***Diagnosis:***

Diagnosis is usually presumptive. When a specific diagnosis is needed, biochemical and molecular biological procedures are available.

### ***Prophylaxis and Treatment:***

Treatment of the common cold includes rest, sufficient fluids to prevent dehydration, and a light, palatable, well balanced diet.

Nasal decongestants may provide temporary relief. An analgesic/antipyretic agent may be given. Cough may be reduced by steam inhalation, with cough-suppressant syrups, or with an expectorant, an agent that promotes the ejection of mucus or exudates from the trachea, bronchi, and lungs.

### ***Control Measures:***

- The application of standard precautions including respiratory hygiene/cough etiquette may reduce the spread of infection.
- It is neither necessary nor feasible to restrict all personnel with acute upper respiratory infection from taking care of patients who are not in high-risk groups.
- Dental health care personnel with respiratory infections should not treat high– risk groups such as the elderly, patients with chronic underlying illness, or immunocompromised patients.

## ***Influenza [6, 12-13, 27, 49-50]***

### ***Causative Microorganism:***

Influenza is an acute respiratory infection caused by influenza viruses. These viruses are single stranded, helical shaped RNA viruses classified in the family Orthomyxoviridae.

The typical incubation period for influenza is 1- 4 days. In most cases infection results in self-limited disease. However, some viral strains have the capacity to cause more severe disease, thereby leading to potentially life-threatening pneumonia in susceptible people.

There are three influenza virus types, termed A, B, and C, which are distinguished by specific antigenic differences in viral components. Influenza A and B viruses cause seasonal epidemics. Influenza type C infections cause a mild respiratory illness and are not thought to cause epidemics. Influenza A viruses are divided into subtypes based on two proteins on the surface of the virus: the hemagglutinin (H) and the neuraminidase (N). There are 16 different hemagglutinin subtypes and 9 different neuraminidase subtypes. Influenza A viruses can be further broken down into different strains.

New viral strains may evolve through antigenic shift (a sudden shift in the antigenicity of a virus resulting from the recombination of the genomes of two viral strains, and seen only with influenza A viruses), and/or antigenic drift (mutation of viruses and their antibody-binding sites which may occur in both influenza A and influenza B viruses). The current subtypes of influenza A viruses found in humans are A (H1N1) and A (H3N2).

Swine flu, which is a respiratory disease of pigs, is caused by a type A influenza virus that regularly causes outbreaks of influenza in pigs. Like all influenza viruses, the swine flu virus changes constantly. Through antigenic shift, the different species of influenza viruses that infect pigs can evolve into new viruses that are a mix of swine, human and/or avian flu viruses. Such novel H1N1 virus can be transmitted from one human to another.

## ***Comparison of Influenza Types***

1. Type A
  - Natural hosts are wild birds.
  - Can infect birds, people, pigs, and other animals.
  - Subtypes based on antigenic differences of hemagglutinin (HA) and neuraminidase (NA) surface proteins.
  - Can cause moderate to severe disease.
  - Can undergo antigenic shift and antigenic drift.
  - Can cause large pandemics with high mortality.
2. Type B
  - Human infection only.
  - Primarily infects children.
  - Generally cause milder disease than type A viruses.
  - Severe cases of flu generally found in elderly or high-risk persons.
  - Can undergo antigenic drift.
  - Do not cause pandemics, only seasonal epidemics.
3. Type C
  - Rarely reported as cause of human influenza.
  - Most infections are asymptomatic.
  - No epidemics seen.

### ***Transmission of the Disease:***

Influenza viruses are spread from person to person primarily through large-particle ( $\geq 5 \mu\text{m}$ ) respiratory droplet emission when an infected person coughs and sneezes near a susceptible person. Transmission via large-particle droplets requires close contact between source and recipient persons, because droplets do not remain suspended in the air and generally travel only a short distance (1 meter) through the air. Contact with respiratory droplet contaminated surfaces is another potential source of transmission.

Adults can be infectious from the day before symptoms begin

through approximately 5 days after onset of illness. Children can be infectious for  $\geq 10$  days after onset of symptoms.

### ***Clinical Features:***

Uncomplicated influenza illness is characterized by the abrupt onset of fever, myalgia, headache, nonproductive cough, sore throat, and rhinitis.

In children otitis media, nausea, and vomiting are also common. Cough and malaise can persist for more than 2 weeks.

Influenza virus infections can cause primary influenza viral pneumonia, exacerbate underlying pulmonary or cardiac disease, lead to secondary bacterial sinusitis, otitis, and pneumonia, or predispose to co-infections with other viral and bacterial pathogens. Rarely, encephalopathy, myositis, myocarditis, pericarditis and Reye syndrome (fatal disease that causes numerous detrimental effects to many organs, especially the brain and liver, as well as causing a lower than usual level of blood sugar) have been reported.

### ***Diagnosis:***

In the absence of laboratory confirmation, it is difficult to distinguish between influenza and illnesses caused by other respiratory pathogens based on signs and symptoms alone. The diagnosis of influenza should be considered in any patient with respiratory symptoms or fever during the influenza season.

### ***Prophylaxis and Treatment:***

Annual vaccination against current influenza A and B subtypes is the most effective method of preventing infection and has been shown to reduce associated complications. Preventing influenza among HCP who might serve as sources of influenza virus transmission provides additional protection to patients at risk for influenza complications. Annual vaccination has been strongly recommended for HCP by the U.S. Centers for Disease Control, Advisory Committee on Immunization Practices (ACIP).

Antiviral agents with activity against influenza viruses can be effec-

tive for the chemoprophylaxis and treatment of influenza.

### **Control Measures:**

- The application of standard precautions, including respiratory hygiene/cough etiquette, in addition to droplet precautions may reduce the spread of infection. The droplet precautions could be terminated after 5 days from onset of symptoms.
- The application of airborne, droplet and contact precautions in addition to standard precautions are needed for patients with H1N1 infection.
- Dental health care personnel with fever and upper respiratory infection during atypical flu outbreaks should take a sick leave for two (2) days until laboratory results are available. If H1N1 infection is confirmed, sick leave should be extended up to 7 days from the first day of fever.
- It is neither necessary nor feasible to restrict all personnel with acute upper respiratory infection from taking care of patients who are not in high-risk groups.
- Dental health care personnel with respiratory infections should not treat high– risk groups such as the elderly, patients with chronic underlying illness, or immunocompromised patients.

### **Rhinosinusitis [6, 12-13, 51-52]**

#### **Causative Microorganism:**

Rhinosinusitis is characterized by inflammation of the paranasal sinuses because of viral, bacterial, or fungal infections, or allergic conditions.

The most common bacterial organisms in community-acquired acute bacterial rhinosinusitis are *Streptococcus pneumoniae*, *Haemophilus influenzae*, *Staphylococcus aureus*, and *Moraxella catarrhalis*. The most common viruses in acute viral rhinosinusitis are rhinovirus, adenovirus, influenza virus, and parainfluenza virus. Respiratory viruses cause most cases of acute rhinosinusitis, and the initial viral infection may be followed by a secondary bacterial infection. Anaerobe bacteria may play a role in chronic rhinosinusitis.

### ***Transmission of the Disease:***

Rhinosinusitis can be transmitted in hospitals and dental settings by droplet and contact transmission. *S. pneumoniae*, *H. influenzae*, and anaerobes have been identified in dental aerosols and contaminated water lines.

### ***Clinical Features:***

Acute and chronic rhinosinusitis produce similar clinical signs and symptoms. Maxillary sinusitis produces pain over the affected sinus, toothache, and a frontal headache. Frontal sinusitis produces pain over the frontal sinus and a frontal headache. Ethmoid sinusitis produces pain behind the eyes and a frontal headache. Sphenoid sinusitis is characterized by malaise and pain referred to the frontal and or occipital areas.

### ***Diagnosis:***

Acute bacterial rhinosinusitis is correctly diagnosed about half the time based on clinical impressions. Acute bacterial rhinosinusitis and viral rhinosinusitis are difficult to differentiate. Bacterial rhinosinusitis may be present if symptoms have been present for more than 7 days and there is localization to the maxillary sinus. Bacterial culture of secretions may be used when resistant pathogens are suspected or if the patient is immunocompromised.

In both acute and chronic rhinosinusitis, the edematous mucous membrane and retained exudates cause the affected sinus to appear radiographically radiopaque. However, sinus radiography is not recommended for routine evaluation of acute, uncomplicated bacterial rhinosinusitis.

### ***Prophylaxis and Treatment:***

Symptoms usually resolve within 7–11 days, and most people recover without medical treatment.

Symptomatic treatment is recommended for patients with acute viral rhinosinusitis; however, if a patient has acute bacterial rhinosinusitis, symptomatic and antibiotic treatment is recommended. Symptomatic

treatment may include antipyretics, analgesics, decongestants, antihistamines mucolytics, intranasal corticosteroids, and saline nasal irrigation.

Antibiotics may be considered in patients with symptoms or signs of acute rhinosinusitis that do not improve within seven days or that worsen at any time; in those with moderate to severe pain or a temperature of 101°F (38.3°C) or higher; and in those who are immunocompromised. For patients allergic to penicillin, trimethoprim/sulfamethoxazole (Bactrim, Septra) or a macrolide may be used. Rhinosinusitis not responding to antibiotic therapy may require surgical intervention.

### ***Control Measures:***

- The application of standard precautions including respiratory hygiene/cough etiquette may reduce the spread of infection.
- Dental health care personnel with fever and upper respiratory infection should take a sick leave for two (2) days and may return to work after initiation of appropriate chemotherapy, depending on their clinical status.
- It is neither necessary nor feasible to restrict all personnel with acute upper respiratory infection from taking care of patients who are not in high-risk groups.
- Dental health care personnel with respiratory infections should not treat high –risk groups such as the elderly, patients with chronic underlying illness, or immunocompromised patients.

## ***Pharyngitis [6, 13, 53]***

### ***Causative Microorganism:***

Acute pharyngitis is usually of viral origin (i.e. rhinovirus, coronavirus, influenza A and B viruses, parainfluenza virus, enterovirus, adenovirus, Epstein Barr virus, herpes simplex virus (HSV), cytomegalovirus, and HIV), but it may also be caused by group A beta-hemolytic streptococci (GABHS), Mycoplasma pneumonia, Chlamydia pneumonia, or other bacteria. Streptococcus pyogenes is the most common bacterial cause of acute pharyngitis.



The incubation period for GABHS is 2-5 days, and that for viral pharyngitis can reach up to 2 weeks.

### ***Transmission of the Disease:***

Viral pharyngitis, and bacterial pharyngitis caused by streptococcus pyogenes (which have been isolated from dental aerosols) are spread by droplet and contact transmission.

Patients with GABHS are considered noncontagious 24 hours after starting therapy.

### ***Clinical Features:***

The hallmark of pharyngitis is a sore throat and pain when swallowing. The pharyngeal mucosa is erythematous and edematous and may be covered by pseudomembraneous purulent exudates. Fever and cervical lymphadenopathy are present.

If untreated, a patient with *S. pyogenes* pharyngitis can develop suppurative and nonsuppurative complications. Suppurative complications include otitis media, sinusitis, peritonsillar/ retropharyngeal abscesses, or mastoiditis. The major nonsuppurative complication is rheumatic fever, a complication that is more likely to occur in children with *S. pyogenes* pharyngitis than in adults with this bacterial infection.

Signs and symptoms of recent fever, tender anterior cervical lymphadenopathy, red pharynx and/or tonsillar swelling or exudate, and no cough indicate a higher probability of GABHS for both adults and children. In addition to rheumatic fever, post-streptococcal glomerulonephritis (PSGN) may occur following GABHS infection (usually occurs after a streptococcal skin infection). Treating GABHS pharyngitis does not appear to diminish the risk of PSGN.

### ***Diagnosis:***

Definitive diagnosis requires culture and susceptibility testing.

### ***Prophylaxis and Treatment:***

Treatment includes rest and the administration of acetaminophen to relieve pain. A regimen of penicillin or erythromycin is initiated to prevent rheumatic fever for those patients with clinical evidence of bacte-

rial pharyngitis, while awaiting the results of culture and susceptibility testing.

***Control Measures:***

- The application of standard precautions including respiratory hygiene/cough etiquette may reduce the spread of infection.
- Dental health care personnel with fever and upper respiratory infection should take a sick leave for two (2) days and may return to work after initiation of appropriate chemotherapy, depending on their clinical status.
- It is neither necessary nor feasible to restrict all personnel with acute upper respiratory infection from taking care of patients who are not in high-risk groups.
- Dental health care personnel with respiratory infections should not treat high –risk groups such as the elderly, patients with chronic underlying illness, or immunocompromised patients.

***Laryngitis [6, 13, 54]***

Laryngitis is defined as inflammation of the larynx. Acute laryngitis may occur during the course of a common cold and influenza or as a complication of measles, pertussis, bronchitis, or pneumonia. Excessive talking or singing, allergies and breathing substances such as tobacco smoke and certain chemicals also can cause acute laryngitis.

***Transmission of the Disease:***

Laryngitis is transmitted by contact and droplet transmission.

***Clinical Features:***

In acute laryngitis, the throat is sore and the voice is hoarse. Later the patient may lose his or her voice altogether. A hoarse or weak voice associated with the common cold may be differentiated from that caused by laryngitis by the duration; hoarseness associated with the common cold will usually disappear after 2 or 3 days. A cough is usually present but is nonproductive unless there is associated tracheitis and bronchitis. Malaise, fever, and/ or dysphasia may be present in more severe infections. Pain is absent or minimal.

### ***Diagnosis:***

Direct laryngoscopy may reveal mild or moderate erythema and edema of the mucous membranes. In chronic laryngitis, the vocal cords may be thickened and red.

### ***Prophylaxis and Treatment:***

Resting the voice, use of steam inhalations and drinking plenty of water promote relief of symptoms associated with acute viral laryngitis.

### ***Control Measures:***

- The application of standard precautions including respiratory hygiene/cough etiquette may reduce the spread of infection.
- Dental health care personnel with fever and upper respiratory infection should take a sick leave for two (2) days and may return to work after initiation of appropriate chemotherapy, depending on their clinical status.
- It is neither necessary nor feasible to restrict all personnel with acute upper respiratory infection from taking care of patients who are not in high-risk groups.
- Dental health care personnel with respiratory infections should not treat high –risk groups such as the elderly, patients with chronic underlying illness, or immunocompromised patients.

## ***Pertussis [13, 27, 55]***

Pertussis, a respiratory illness commonly known as whooping cough, is a highly contagious infection.

### ***Causative Microorganism:***

Pertussis is caused by a type of bacteria called *Bordetella pertussis*. These bacteria attach to the cilia that line part of the upper respiratory system. The bacteria release toxins, which damage the cilia and cause inflammation. The incubation period is generally 7–10 days but can be as long as 21 days.

### ***Transmission of the Disease:***

Transmission occurs by direct contact with respiratory secretions or

large aerosolized droplets from the respiratory tract of infected persons (by coughing or sneezing). The period of communicability starts with the onset of the catarrhal stage and extends into the paroxysmal stage (see Clinical Features).. The disease can be transmitted from adults to close contacts, especially unvaccinated children. Vaccinated adolescents and adults, whose immunity from childhood vaccinations wanes 5–10 years after the most recent dose of vaccine (usually administered at age 4–6 years), are an important source of pertussis infection for susceptible infants.

In hospital settings, transmission of pertussis has occurred from hospital visitors to patients, from HCP to patients, and from patients to HCP.

### ***Clinical Features:***

Symptoms of early pertussis (catarrhal phase) are indistinguishable from other upper respiratory infections. These early symptoms (catarrhal stage) can last for 1 to 2 weeks and usually include: runny nose; low-grade fever (generally minimal throughout the course of the disease), mild and occasional cough; and apnea in infants. Because pertussis in its early stages appears to be nothing more than the common cold, it is often not suspected or diagnosed until the more severe symptoms appear. Infected people are most contagious during this time, up to about 2 weeks after the cough begins.

As the disease progresses, the traditional symptoms (paroxysmal stage) of pertussis appear and include: paroxysms (fits) of many rapid coughs followed by a high-pitched “whoop” that continues for weeks; vomiting; exhaustion (very tired) after coughing fits. Paroxysmal stage lasts for 1-6 weeks and may extend up to 10 weeks. Coughing fits generally become more common and severe as the illness continues, and can occur more often at night. Pertussis can cause serious and sometimes life-threatening complications in infants and young children, especially those who are not fully vaccinated. Infants too young to be vaccinated are at greatest risk for severe pertussis, including hospitalization and death.

The illness can be milder (less severe) and the typical “whoop” ab-

sent in children, teens, and adults who have been vaccinated.

Recovery from pertussis can happen slowly. The cough becomes less severe and less common. However, coughing fits can return with other respiratory infections for many months after pertussis started.

### ***Prophylaxis and Treatment:***

Pertussis is generally treated with antibiotics and early treatment is very important. Treatment may make the infection less severe if it is started early, before coughing fits begin, and it may shorten the amount of time someone is contagious.

Vaccinations are available for children for diphtheria, tetanus toxoids and acellular pertussis (DTaP vaccine). The pertussis booster vaccine for adolescents and adults is called Tdap.

### ***Control Measures:***

- The application of standard precautions including respiratory hygiene/cough etiquette in addition to droplet precautions may reduce the spread of infection.
- The droplet precautions could be terminated after 5 days of starting effective antimicrobial therapy.
- Postexposure prophylaxis is necessary for HCP in contact with persons at risk for severe disease.
- Other HCP either should receive postexposure prophylaxis or be monitored for 21 days after pertussis exposure and treated at the onset of signs and symptoms of pertussis.
- Recommended postexposure prophylaxis antibiotics for HCP exposed to pertussis include azithromycin, clarithromycin, or erythromycin.
- Dental health care personnel with active Pertussis and exposed symptomatic DHCP should be excluded from duty from the beginning of the catarrhal stage through 3rd week after onset of paroxysms (active DHCP) or until 5days after start of effective antimicrobial therapy (active and exposed symptomatic DHCP).

## Lower Respiratory Tract Infections

### ***Acute Tracheobronchitis [6, 56]***

It is an inflammatory response of the tracheobronchial tree to infections. Acute bronchitis usually follows an upper respiratory tract infection that extends into the trachea and bronchi, and results in cough and sputum production. Environmental pollutants and the inhalation of various allergens are predisposing or contributory factors.

#### ***Causative Microorganism:***

Viruses are by far the most common etiologies (i.e. Respiratory syncytial virus (RSV), Adenovirus, Influenza, and Parainfluenza viruses). In young adults acute bronchitis may be associated with *Mycoplasma pneumoniae*, *Bordetella pertussis*, and *Chlamydia pneumoniae* infections.

#### ***Transmission of the Disease:***

Tracheobronchitis is spread by droplet and contact transmission.

#### ***Clinical Features:***

The disease causes soreness behind the sternum and a dry, painful, nonproductive cough. The patient wheezes and has difficulty breathing. Acute tracheobronchitis is a self-limiting disease in healthy adults and most symptoms resolves within 2 weeks, but the cough can last for up to 8 weeks in some people.

As secondary bacterial infection occurs, thick purulent sputum is produced. Malaise and fever for up to 5 days is common. Persistent fever suggests complicating pneumonia.

#### ***Diagnosis:***

Diagnosis is usually based on clinical signs and symptoms. Gram stain and culture should be performed to identify the causative organism. A chest x-ray is also indicated to rule out other diseases for patients presenting with severe disease symptoms.

#### ***Prophylaxis and Treatment:***

Rest, oral fluids, and an antipyretic are indicated. Antibiotics are in-

dicted when purulent sputum is present, when high fever persists, and in patients with chronic obstructive pulmonary disease.

***Control Measures:***

- The application of standard precautions including respiratory hygiene/cough etiquette may reduce the spread of infection.
- Dental health care personnel with fever and respiratory infection should take a sick leave for two (2) days and may return to work after initiation of appropriate chemotherapy, depending on their clinical status.
- It is neither necessary nor feasible to restrict all personnel with acute respiratory infection from taking care of patients who are not in high-risk groups.
- Dental health care personnel with respiratory infections should not treat high –risk groups such as the elderly, patients with chronic underlying illness, or immunocompromised patients.

***Pneumonia [6, 13]***

Staphylococcal pneumonia occurs primarily in children, patients with altered pulmonary function, and hospitalized patients. This life-threatening secondary infection is frequently noted during influenza epidemics.

***Causative Microorganism:***

Bacteria are the most common causes of pneumonia. Defective leukocyte activity predisposes patients to infections with pneumococci, streptococci, Haemophilus influenza, and Pneumocystic carinii. Streptococcus pneumoniae (pneumococci) strains are responsible for 98% of the infections, with staphylococci accounting for 1%.

***Transmission of the Disease:***

The organisms are spread by droplet nuclei (inhalation) and by aspiration from the upper respiratory tract.

***Clinical Features:***

Signs and symptoms include a rapidly rising fever, a painful cough, and the production of purulent sputum sometimes mixed with blood

(hemoptysis). The patient experiences pain on respiration, and as a result, breathing becomes rapid and shallow.

### ***Diagnosis:***

Diagnosis is based on clinical signs and symptoms in conjunction with the radiographic distribution of the infiltrate. Culturing expectorated sputum is the most practical method of identifying bacterial pathogens. A lung biopsy may be required to determine a specific etiological agent.

### ***Prophylaxis and Treatment:***

Treatment consists of respiratory support and the administration of appropriate antimicrobial agents.

### ***Control Measures:***

- The application of standard precautions including respiratory hygiene/cough etiquette in addition to droplet precaution (in case of pneumonia caused by Haemophilus influenzae type b and Neisseria Meningitidis ) may reduce the spread of infection.
- Dental health care personnel with fever and respiratory infection should take a sick leave for two (2) days and may return to work after initiation of appropriate chemotherapy, depending on their clinical status.
- It is neither necessary nor feasible to restrict all personnel with acute respiratory infection from taking care of patients who are not in high-risk groups.

## ***Legionnaire's Disease [4, 57]***

### ***Causative Microorganism:***

The Legionella pneumophila bacterium is responsible for two acute bacterial diseases: Pontiac fever and Legionnaires' disease. The L. pneumophila bacteria have been found to thrive in lakes, air-conditioning systems, shower heads, water distillation systems, and the biofilm found in dental unit water lines.

### ***Transmission of the Disease:***

The bacteria are transmitted through aerosolization and aspiration



of contaminated water and it is not transmitted from person to person.

### ***Clinical Features:***

The least serious form of infection is called Pontiac fever and causes acute flu like symptoms with headache, high fever, dry cough, chills, diarrhea, and pleural and abdominal pain. The more serious form of infection is called Legionnaire's disease and causes a very severe pneumonia. In individuals who are already immunocompromised or elderly, the disease can be fatal.

### ***Control Measures:***

- Application of standard precautions.
- Regular cleaning and maintenance of different water lines.
- Regular cleaning and maintenance of air conditioning systems.

## ***Tuberculosis [4, 6, 10, 13, 58-59]***

Tuberculosis (TB), which is caused by the bacterium *Mycobacterium tuberculosis*, is the leading cause of death worldwide from infectious diseases. Although it involves primarily the lungs, it can affect any organ or tissue, including the oral cavity.

Patients infected with *Mycobacterium tuberculosis* occasionally seek urgent dental treatment at outpatient dental settings. Understanding the pathogenesis of the development of TB will help DHCP determine how to manage such patients. Although the risk of transmission of *M. tuberculosis* in dental settings is low, it is important for DHCP to include protocols for TB infection control in their offices' written infection control program.

Infection is most likely to occur when a patient has unsuspected pulmonary or laryngeal TB, has bacillus-laden sputum or respiratory secretions, and is coughing or sneezing into air that remains in circulation.

### ***Epidemiology:***

An estimated 2 billion persons (one-third of the world's population) are infected globally with *M. tuberculosis*. Most infections do not lead to symptomatic TB.

Active symptomatic disease is curable, yet TB kills 5,000 people every day. This chronic infection is the single most frequent cause of death in the world from one infectious agent. One symptomatic person infects 10-15 others each year.

### ***Causative Microorganism:***

Mycobacterium tuberculosis is a rod-shaped tubercle bacillus carried in airborne infective droplet nuclei. These small particles (1-5  $\mu\text{m}$ ) can stay suspended in the air for hours and can be carried in normal air currents throughout a room or building.

### ***Transmission of the Disease:***

Tuberculosis is not a highly contagious disease in that *M. tuberculosis* requires prolonged or frequent close contact with an infectious source for transmission to a susceptible host. Infection occurs when a susceptible person inhales droplet nuclei containing *M. tuberculosis*, which then travel to the alveoli of the lungs. These droplet nuclei can be generated when persons with pulmonary or laryngeal TB sneeze, cough, speak, or sing. The probability that a person who is exposed to *M. tuberculosis* will become infected depends on the concentration of infectious droplet nuclei in the air and the duration of the exposure to a person with infectious, active disease. Environmental factors such as exposure in confined spaces, inadequate ventilation, and recirculation of air containing infectious droplet nuclei further increase the likelihood of transmission. Persons at highest risk for exposure to and infections with *M. tuberculosis* are close contacts (who share air space in a household or other enclosed environment) of persons with pulmonary tuberculosis.

Usually within 2-12 weeks after initial infection with *M. tuberculosis*, immune response prevents further spread of the TB bacteria, although they can remain alive in the lungs for years, a condition termed latent TB infection (LTB1). Reactivation of these bacteria can occur frequently as the result of malnutrition, debilitation, immunosuppression (AIDS, immunosuppressive therapy, Diabetes Mellitus) or other forms of stress. Persons with latent TB infection usually exhibit a reactive tuberculin skin test (TST), have no symptoms of active disease, no

radiographic abnormalities, no positive culture test, and are not infectious. However, they can develop active disease later in life if they do not receive treatment for their latent infection.

Ninety percent of people who are exposed to tuberculosis have latent TB infection. They carry the microorganism without active symptoms. They do not transmit the disease at this stage; however, if resistance is weakened, the tuberculosis may become active.

### ***Risk in the Dental Operatory:***

Tuberculosis is a great health risk for healthcare workers. One reason for this is that the bacteria are able to withstand disinfectants that kill many other bacteria. But, overall, the risk borne by DHCP for exposure to a patient with active TB disease is probably low and TST conversions among DHCP are also low.

While there is a paucity of data linking dental instrumentation to the generation of droplet nuclei containing *Mycobacterium tuberculosis*, it can be anticipated that DHCP and patients with infectious tuberculosis (TB) will generate droplet nuclei by coughing, sneezing, laughing and talking. The probable transmission of multiple drug-resistant tuberculosis (MDRTB) disease from patients to 2 DHCP has been documented and there is evidence of TB disease transmission from an oral surgeon to 15 patients following extractions.

### ***Clinical Features:***

Symptoms of active TB disease include a productive and persistent cough, bloody sputum, night sweats, fatigue, malaise, unexplained weight loss, fever or anorexia or a combination of these. Infected sputum may cause tuberculous tracheitis, laryngitis, and tuberculous ulcers on the tonsils, nasal and oral cavities.

Certain immunocompromising medical conditions (e.g., HIV) increase the risk that TB infection will progress to active disease at a faster rate. So, if any of the following signs are present, it may be necessary to refer the patient for diagnosis and treatment before providing dental care:

- A productive cough lasting longer than 3 weeks.

- Unexplained fever, fatigue, night sweats, hoarseness or chest pain.
- Unexplained weight loss and anorexia (loss of appetite).
- Being a member of a high-risk group.

### ***Diagnosis:***

Definitive diagnosis of active TB disease requires the demonstration of bacteria in the patient's tissues or secretions. Bacteriologic examination includes obtaining a specimen of sputum. Detection of acid-fast bacilli (AFB) in stained smears examined microscopically can provide the first bacteriologic clue to clinical disease. DNA probes specific for the genus mycobacterium now are used routinely to identify specific bacteria.

Presumptive diagnosis of *M. tuberculosis* infection clinically relies on conversion of the infected person to a positive type IV( delayed) hypersensitivity state as shown by the Tuberculin Skin Test (TST). Two steps tuberculin skin test may be indicated annually for clinical personnel who risk exposure to this disease, but test results are not always accurate. When there is any doubt concerning these test results, radiographs and laboratory tests are necessary to establish a more definitive diagnosis. The CDC recommends that persons with a positive TST undergo further evaluation, including a chest radiograph to determine whether the person has TB disease.

In some people infected with TB in the past, the body loses its ability to react to the tuberculin antigen. When these people receive a TST many years after the initial infection, they may have a negative reaction. However, if they are tested a second time, they may have a positive reaction owing to a boosted response to the tuberculin solution. At baseline testing, if the results of the first and second tests are negative, the person is considered uninfected. If the first test result is positive or the first test result is negative and the second result is positive, the person should be evaluated by a physician for latent TB infection or active disease.

New blood assays for *M. tuberculosis* (BAMTs), called "interferon

gamma release assays” (IGRAs), have been developed for use as an aid in diagnosing LTBI infection and TB disease. IGRAs can be used in all circumstances in which the TST is currently used. The advantages of the BAMT versus the TST are that:

1. it requires a single patient visit to draw a blood sample; results can be available within 24 hours;
2. it does not boost responses (as measured by means of subsequent tests), as can happen with the TST;
3. it is not subject to the reader bias that can occur with the TST;
4. it is not affected by prior BCG vaccination (Bacillus Calmette-Guérin, vaccine against Mycobacterium tuberculosis- see vaccination section).

The CDC 2005 revision of the TB infection control guidelines includes general recommendations regarding the use of blood assays for *M. tuberculosis* as part of the infection control program in health care settings.

### ***Prophylaxis and Treatment:***

The two most effective drugs that are used to treat the disease are isoniazid and rifampin. However, multidrug resistant (MDR) TB is resistant to the most effective first-line therapeutic drugs. The prevalence of MDR TB has increased globally owing to the misuse and mismanagement of anti-TB drugs, incomplete treatment, and an inadequate drug supply.

There is no effective form of protective immunization against tuberculosis.

### ***Control Measures:***

- While standard precautions reduce the risk of occupational exposure to most organisms responsible for upper respiratory tract infections, they are inadequate to prevent the spread of *M. tuberculosis*. Surgical masks do not prevent inhalation of *M. tuberculosis* droplet nuclei. To prevent the cross infection in these instances, transmission based precautions (airborne

precautions) are necessary.

- The primary risk of exposure to *M. tuberculosis* in the dental healthcare setting is contact with patients with undiagnosed or unsuspected infectious disease.
- Minimum requirements in a community based dental health-care setting is implementation and enforcement of a TB infection control protocol that provides for prompt: (a) identification of patients with suspected or confirmed infectious TB disease, (b) isolation of patients with suspected and confirmed TB disease from other patients and DHCP, and (c) referral of patients with suspected or confirmed symptomatic disease who require dental healthcare to a facility with appropriate environmental controls and respiratory protection controls.
- Dental health care personnel should be trained to recognize signs and symptoms to help with prompt detection.
- While taking patients' initial medical histories and at periodic updates, dental DHCP should routinely ask all patients whether they have a history of TB disease, symptoms indicative of TB or medical conditions that increase the risk of TB disease.
- Patients with a medical history or symptoms indicative of undiagnosed active TB should be referred promptly for medical evaluation to determine possible infectiousness. Such patients should not remain in the dental-care facility any longer than required to evaluate their dental condition and arrange a referral. While in the dental health-care facility, the patient should be isolated from other patients and DHCP, instructed to observe strict respiratory hygiene and cough etiquette procedure and wear a surgical mask when not being evaluated. When coughing or sneezing they should turn their heads away from other persons and cover their mouth and nose with their hands or preferably a cloth or tissue.
- Routine dental care should be postponed until a physician confirms that the patient does not have infectious TB disease or if the patient is diagnosed with active TB disease, until con-

firmed the patient is no longer infectious.

- If urgent dental care is provided for a patient who has, or is suspected of having active TB disease, the care should be provided in a facility (e.g., hospital) that provides airborne infection isolation.
- **Dental Health Care Personnel:**
  - A tuberculosis screening and prevention program for DHCP is important in protecting personnel and patients. The facility's level of TB risk will determine the need for routine follow-up screening (Table 6).
  - Screening Program:
    - All newly arrived DHCP should have a chest x-ray, and a two-step tuberculin skin test or single blood assay, interferon gamma release assay prior to employment. Those already known to have significant reactions need not be retested.
    - Any DHCP with a persistent cough (i.e., lasting >3 weeks), especially in the presence of other signs or symptoms compatible with active TB (e.g., weight loss, night sweats, fatigue, bloody sputum, anorexia, or fever), should be evaluated promptly.
    - A two-step procedure can be used to minimize the likelihood of misinterpreting a boosted reaction as a true conversion due to a recent infection. In the two-step procedure, an initial tuberculin skin-test is given. If this test result is 0-9 mm of induration, a second test is given at least one week and no more than three weeks after the first. The result of the second test is used as the base line test in determining treatment and follow-up of these personnel.
    - For DHCP with documented negative tuberculin skin tests and considered to be at significant risk, repeat skin tests will be necessary on a yearly basis.
    - Skin-test reaction after BCG vaccination may be quite

variable, and it cannot be distinguished from that due to virulent tuberculous infection. Caution is necessary in attributing a significant skin-test reaction to previous BCG vaccination, especially if the person vaccinated has recently been exposed to infective tuberculosis. Skin test reactivity tends to diminish with time, and by 10 years after BCG vaccination, most recipients do not have a significant reaction (i.e., 10 mm or more of induration). At any time, a reaction greater than 15 mm is not likely to be due to BCG. It is prudent to manage a significant reaction in BCG-vaccinated persons as a possible tuberculous infection.

- All DHCP with positive test results should be evaluated promptly for active disease. A thorough history of exposure to *M. tuberculosis* should be obtained to determine whether the infection is occupational or community acquired. Baseline positive and newly positive DHCP (significant skin-test reaction), those who have pulmonary symptoms that may be due to TB, and those with documented treatment for LTB1 or TB disease should receive one chest radiograph as part of the evaluation to rule out TB disease. If the result of the initial radiographic examination is negative no further radiographs are necessary unless symptoms suggestive of TB disease develop. Periodically, DHCP with positive test results should be reminded about the signs and symptoms of TB disease and the need for prompt evaluation of any pulmonary symptoms.
- According to CDC guidelines, all dental settings, regardless of risk category, should develop a written TB infection control plan as part of their overall infection control programs. Specifics of TB infection control programs will differ, depending on whether patients with suspected or confirmed TB are likely to seek treatment in each setting.
- According to CDC guidelines, all dental settings should



also conduct an initial and annual assessment of the risk of TB transmission, regardless of the likelihood of encountering people with TB disease.

- A dental setting's TB infection control program should be based on a three-level hierarchy of TB infection control measures: administrative controls, environmental controls and respiratory protection (RP) controls.

- a. Administrative Controls

1. Assigning responsibility for managing TB infection control program.
2. Annual risk assessment should be conducted.
3. Written TB infection control policies should be developed for promptly identifying and isolating patients with suspected or confirmed TB disease for medical evaluation or urgent dental treatment.
4. Patients should be instructed to cover mouth when coughing and/or wear a surgical mask
5. Ensuring that DHCP are educated regarding signs and symptoms of TB.
6. Ensuring that all newly hired DHCP are screened for latent TB infection and TB disease.
7. Postponing of routine dental treatment.

- b. Environmental Controls

1. Airborne infection isolation room should be used to provide urgent dental treatment to patients with suspected or confirmed infectious TB.
2. In settings with high volume of patients with suspected or confirmed TB, high-efficiency particulate air filters or ultraviolet germicidal irradiation should be used.

- c. Respiratory Protection Controls
  1. N95 (at a minimum) disposable respirators should be used by DHCP when they are providing urgent dental treatment to patients with suspected or confirmed TB.
  2. TB patients should be instructed to cover mouth when coughing and to wear a surgical mask.

**Table 6**

Tuberculosis (TB) Risk Categories and Recommended Testing Frequency

Risk Category	Risk Classification	TB Testing Frequency
Low	People with TB disease unlikely to be seen Fewer than three patients with unrecognized TB treated in past year	Baseline, at hiring*; Further testing not needed unless exposure occurs Newly hired DHCP working in a low-risk setting should receive a baseline two-step TST or a single BAMT.
Medium	People with TB disease likely to be seen Three or more patients with unrecognized TB treated in past year	Baseline*, then annually
Potential Ongoing Transmission	Evidence of ongoing person-to-person transmission	Baseline*, then every 8 -10 weeks until evidence of transmission has ceased
Baseline screening should be conducted using a two-step tuberculin skin test or single blood assay, interferon gamma release assay.		

Source: Jensen, et al. [59]

**Management of Exposure to *M. tuberculosis*:**

1. As soon as possible after an exposure to *M. tuberculosis* for whom proper isolation precautions have not been implemented, TST or blood assay for *M. tuberculosis* (BAMT) test-

ing should be done on DHCP known to have had negative results from previous testing. If the initial post-exposure test is negative, repeat the test 10-12 weeks after exposure ( the upper limit of time required for an infected person to develop hypersensitivity to tuberculin).

2. Those that have significant reactions on testing need chest X-rays to exclude the possibility of tuberculous pulmonary disease. If chest films are normal, these persons can be advised to receive preventive therapy (i.e., chemoprophylaxis with oral isoniazid (INH) 300 mg and pyridoxine 25 mg daily for 9-12 months). If the chest film has abnormalities compatible with pulmonary TB, these personnel need evaluation to rule out the possibility of active disease.
3. All DHCP with active TB disease should be excluded from the workplace until documentation is provided from their healthcare provider that they are: a) receiving adequate therapy, (b) their cough has resolved and (c) that they have had three consecutive sputum smears collected with negative results for AFB. After returning to work, they should obtain periodic documentation from their healthcare provider that effective drug therapy has been maintained for the recommended period of time and that sputum smears remain negative for AFB.
4. Household contacts of DHCP who develops active pulmonary tuberculosis will be screened and, if indicated, treated.

## Herpetoviruses [4, 7, 60]

A herpesvirus is a double-stranded DNA virus that causes infections. Of the many herpesviruses that have been identified, eight are known to affect human:

1. **Herpes Simplex Virus Type 1** (HSV 1), which causes primarily oral lesions
2. **Herpes Simplex Virus Type 2** (HSV 2), which causes primarily genital lesions.
3. **Herpes Zoster or Varicella-Zoster Virus** (HZV) causes herpes zoster, shingles, and chickenpox.
4. **The Cytomegalovirus** (CMV) is normally latent (does not produce disease) but may become active when the immune system is damaged (once active, it is highly contagious and is transmitted by most body fluids).
5. **The Epstein-Barr virus** (EBV) causes infectious mononucleosis and Burkitt's lymphoma, which is a malignant neoplasm involving lymphatic tissues.
6. **Herpes Lymphotropic Virus**
7. **Human Herpes Virus 7**
8. **Kaposi's Sarcoma Related Virus**

### **Herpes Simplex Virus Type I**

#### **Causative Microorganism:**

This disease, which is highly contagious, makes its first appearance in very young children (1 to 3 years of age) and is known as primary herpes.

After this initial childhood infection, the virus of herpes simplex lies dormant (residing in the neurons of either the trigeminal ganglion or the sacral ganglia ) and reappears later in life. Recurrences tend to

take place when the patient's general resistance is lowered as a result of stress, fever, illness, injury, and exposure to the sun. Care must be taken by the patient because autoinfection (to the eye, nose, or genitals, for example) is possible, as is infection of other people.

### ***Clinical Features:***

When clinical disease is evident, gingivostomatitis and pharyngitis are the most frequent manifestation. The child may have a slight fever, pain in the mouth, increased salivation, and bad breath. The inside of the mouth becomes swollen, and the gingivae are inflamed. Before the appearance of local lesions, there may be burning sensation with slight swelling as prodrome.

Subsequently, a variable number of vesicles develop on the oral mucosa, the tongue and gingiva. These vesicles eventually rupture and coalesce, and crusting follows. The lesions are infectious, with viral shedding. The lesions then develop into small round or irregular superficial ulcers with erythematous halos and grayish-yellow bases. Healing begins naturally within 3 days, and the illness is usually over in 7 to 14 days.

In the second stage of the disease, the characteristic sore usually appears at the mucocutaneous junction of the lip or on the skin adjacent to the nostrils. This manifestation is known as recurrent herpes labialis. As in the case of primary herpes, recurrent herpes labialis sores heal by themselves in 7 to 10 days, leaving no scar.

Herpes simplex virus has been implicated in Bell's palsy and in oral cancer.

## ***Herpes Simplex Virus Type 2 [4, 13, 21, 60]***

### ***Causative Microorganism:***

Herpes simplex virus type 2 is also known as genital herpes, but it also occurs as an oral and perioral infection.

### ***Herpes Transmission:***

The major transmission route for the herpetovirus is through direct contact either with primary or recurrent lesions or with secretions, such as saliva, vaginal secretions or infected amniotic fluid, that contain the virus when no lesions are obvious.

### ***Risk in the Dental Operatory:***

Herpes simplex viruses I and II are frequently in the mouth of dental patients and may lead to serious infection for the dentist or staff. Dentists may develop an infection of the fingers (herpetic whitlow) which can also be a primary or recurrent infection of HSV, causing severe pain on pressure and inability to practice dentistry. Transmission results from direct contact with a vesicular lesion on a patient's lip or with saliva that contains the viruses. Avoidance of direct contact with lesions, wearing gloves for all contact with oral secretions, and thorough handwashing after patient contact will protect DHCP from such infections.

Dental health care personnel with herpetic whitlow should not have direct contact with patients until their lesions have healed. A dental hygienist with herpes simplex virus I infection on her fingers reportedly transmitted herpes gingivostomatitis to 20 patients.

Protective eyewear is particularly important because the most serious infection, ocular herpes, which can be a primary or recurrent infection of HSV, may lead to blindness. Transmission results from splashing saliva or fluid from a vesicular lesion directly into unprotected eyes.

### ***Clinical Features:***

Within 1 week, clusters of painful blisters develop on the mucosal tissue of the genital area. Once a person is infected, outbreaks will recur even without reinfection. The disease can be transmitted only during these recurrences.

A mother with active vaginal or cervical herpetic lesions at the time of delivery can pass the virus to her newborn. Of the infants infected, at least 85% may be born with severe health problems or deformities, or killed by the virus.

### ***Prophylaxis and Treatment:***

Antiviral therapy can suppress HSV2 lesions. Acyclovir, an antiviral drug, has been used in topical, oral, and intravenous forms. Acyclovir is a selective inhibitor of replication of HSV and varicella-zoster virus. It is established as the drug of choice for treatment of a wide range of infections caused by HCV and VZV.

### ***Control Measures:***

- Standard precautions should be applied to reduce the spread of infection.
- When oral lesions are present, the patient may be asked to reschedule his/ her appointment for a time after the lesions have healed.
- If urgent dental care is provided for a patient with oral lesions, contact precautions in addition to standard precautions should be applied to reduce the spread of infection.
- Even when there are no active lesions, there is still the possibility of transmission through saliva or the aerosol spray from the dental handpiece.
- Because there is no preventive vaccine to protect against herpes, it is essential that precautions be taken to prevent exposure.
- Dental health care personnel with herpetic whitlow should be restricted from patient contact and contact with the patient's environment until lesions heal.
- For DHCP with orofacial lesion, restriction from care of high-risk patients should be considered.

### ***Herpes Zoster or Varicella-Zoster Virus [13, 27, 60-62]***

Infection with varicella zoster virus (VZV) causes two distinct clinical conditions.

1. Primary VZV infection causes varicella (i.e., chickenpox).
2. Herpes zoster (zoster) (i.e., shingles).

### ***Varicella (Chickenpox)***

Chickenpox is a highly contagious rash illness that typically occurs among children. It is occasionally found in adults not previously exposed. Chickenpox may be life threatening in children who are immunocompromised, such as children with HIV infection. When primary maternal VZV occurs during pregnancy or during the peripartum pe-

riod, fetal infection may result in congenital malformations.

### ***Causative Microorganism:***

The varicella zoster virus gains access to epidermal cells, causing the typical varicella rash. The virus then enters sensory nerves in mucocutaneous sites and travels to the sensory dorsal root ganglia adjacent to the spinal cord where the virus establishes permanent latency in neuronal cell bodies.

### ***Transmission of the Disease:***

Chickenpox may be transmitted by direct contact, by droplet (possibly airborne), by inhalation of aerosols from vesicular fluid of skin lesions, or by indirect contact with articles soiled by discharges from the vesicles and respiratory tract. The average incubation period is 14–16 days after exposure to rash (range: 10–21 days). Infected persons are contagious an estimated 1–2 days before rash onset until all lesions are crust, typically 4–7 days after rash onset. Contagiousness is more prolonged in patients with altered immunity. Susceptible individuals should be considered infectious for 10-21 days following exposure.

### ***Clinical Features:***

The disease is characterized by a maculopapular rash that becomes vesicular in a few days and then scabs. If the itchy, crusted lesions of the skin are scratched, a secondary bacterial infection can result. When oral lesions occur, they may spread into the upper respiratory tract.

### ***Prophylaxis and Treatment:***

A vaccine for preventing initial VZV infection has been available since 1995. The CDC- ACIP recommends routine varicella vaccination for all persons aged  $\geq 12$  months who lack evidence of immunity. Varicella vaccination has dramatically reduced chickenpox cases among children.

### ***Control Measures:***

- In addition to standard precautions, airborne and contact precautions should be applied to reduce the spread of infection.
- Airborne and contact precautions could be terminated when lesions dry.



- Susceptible DHCP (not immune) should not treat patients known or suspected to have varicella if other immune DHCP is available. If susceptible DHCP must treat patients known or suspected to have varicella, DHCP should wear respiratory protection (N95 respirator). DHCP immune to varicella need not wear respiratory protection when dealing with varicella patients.
- Dental health care personnel with varicella should be excluded from work facility until all lesions are dry and crusted. If only lesions that do not crust (i.e., macules and papules) are present, the work restriction should stay in effect until no new lesions appear within a 24-hour period.
- For susceptible exposed DHCP, post-exposure vaccine within 120 hours or varicella zoster immunoglobulin (VZIG) within 96 hours should be provided:
  1. Dental health care personnel who have received 2 doses of vaccine and who are exposed to VZV should be monitored daily during days 8–21 after exposure for fever, skin lesions, and systemic symptoms suggestive of varicella.
    - Dental health care personnel can be monitored directly or instructed to report fever, headache, or other constitutional symptoms and any atypical skin lesions immediately.
    - If symptoms occur, DHCP should be excluded from work facility immediately until all lesions are dry and crusted. If only lesions that do not crust (i.e., macules and papules) are present, the work restriction should stay in effect until no new lesions appear within a 24-hour period.
    - If illness occurs, with or without postexposure vaccination, antiviral treatment (e.g., acyclovir) can be considered for adolescents and adults.

2. Dental health care personnel who have received 1 dose of vaccine and who are exposed to VZV should receive the second dose within 3–5 days after exposure to rash (provided 4 weeks have elapsed after the first dose).
  - After vaccination, management is similar to that of 2-dose vaccine recipients.
  - Those who did not receive a second dose or who received the second dose more than 5 days after exposure should be excluded from work from 8th day after 1st exposure through 21st day (28th day if varicella-zoster immune globulin administered) after the last exposure to the virus. And if varicella occurs, the work restriction applies until all lesions are dry and crusted or, if only lesions that do not crust (i.e., macules and papules) are present, until no new lesions appear within a 24-hour period.
3. Unvaccinated DHCP who have no other evidence of immunity and are exposed to VZV are potentially infective from 8th day through 21st day after exposure and should be excluded from the facility during this period.
  - They should receive postexposure vaccination as soon as possible.
  - Vaccination within 3–5 days of exposure to rash might modify the disease if infection occurred.
  - Vaccination after 5 days of exposure is still indicated because it induces protection against subsequent exposures (if the current exposure did not cause infection).
  - For DHCP at risk for severe disease, for whom varicella vaccination is contraindicated, administration of varicella-zoster immune globulin (VZIG) is recommended after exposure.

- VZIG is expected to provide maximum benefit when administered as soon as possible after exposure, although it can be effective if administered as late as 96 hours after exposure; treatment after 96 hours is of uncertain value. VZIG should be administered intramuscularly as directed by the manufacturer.
- Any patient who receives VZIG to prevent varicella subsequently should receive varicella vaccine, provided the vaccine is not contraindicated.
- Varicella vaccination should be delayed until 5 months after VZIG administration. Varicella vaccine is not needed if the patient has varicella after administration of VZIG.
- The patient groups recommended by ACIP to receive VZIG include the following:
  1. Pregnant women.
  2. Neonates whose mothers have signs and symptoms of varicella around the time of delivery.
  3. All premature infants born to susceptible mothers.
  4. Infants born at <28 weeks' gestation or who weigh  $\leq 1000$  g.
  5. Immunocompromised persons of all ages.

### ***Zoster (Shingles)***

VZV can reactivate clinically decades after initial infection to cause herpes zoster ( shingles), a localized and generally painful cutaneous eruption that occurs most frequently among older adults.

#### ***Causative Microorganism:***

Latent VZV is present in approximately 1%-7% of sensory ganglion neurons. As with other members of the herpesvirus family, VZV is noninfectious in its latent form but can reactivate at a later time to form intact virions in the involved sensory neurons. These virions then migrate to the skin through axons, spread from cell to cell, and penetrate the epidermis. Reactivation in

adulthood may result from immunosuppression, such as from drug therapy or from HIV infection, and in people with advanced neoplastic disease. Approximately one in three persons will develop zoster during their lifetime.

### ***Transmission of the Disease:***

Zoster lesions contain high concentrations of VZV that can be spread by the airborne and contact routes, and cause primary varicella in exposed susceptible persons. Localized zoster is transmitted by contact route: direct skin to skin contact with vesicular fluid from patients with zoster lesions. Localized zoster is only contagious after the rash erupts and until the lesions crust.

Zoster has a lower rate of transmission than varicella, unless it is disseminated (Generalized) which usually occurs in immunocompromised patients. In hospital settings, transmission has been documented between patients or from patients to health-care personnel, but transmission from health-care personnel to patients has not been documented.

Persons with localized zoster are less likely to transmit VZV to susceptible persons in their household or occupational settings if their lesions are covered.

### ***Clinical Features:***

Zoster is a localized, generally painful cutaneous eruption that occurs most frequently among older adults and immunocompromised persons. In its full clinical expression, zoster causes pain, which is followed by a localized unilateral vesicular rash associated with the nerve endings of the area innervated by the infected sensory nerves. When the second division of the trigeminal nerve is involved, intraoral lesions may occur.

The clinical course of acute zoster is variable. It is usually less severe in children and younger adults. Typically, zoster begins with a prodrome. Headache, photophobia, and malaise might occur, with fever being less common. Abnormal skin sensations and pain of varying severity are the most common symptoms. These symptoms can precede the zoster rash by days to weeks and rarely might be the only clinical manifestation of VZV reactivation. Pain is described as aching, burning, stabbing, or shock-like. Altered sensitivity to touch, pain provoked

by trivial stimuli, and unbearable itching are all frequently reported.

Zoster rash is typically unilateral and does not cross the mid-line. The rash is initially erythematous and maculopapular but progresses to form coalescing clusters of clear vesicles containing high concentrations of VZV. The vesicles form over several days and then evolve through pustular, ulcer, and crust stages. The rash usually lasts 7--10 days, with complete healing within 2-4 weeks. However, pigmentation changes and scarring might be permanent.

Idiopathic facial palsy (Bell's palsy) might be caused by inapparent VZV reactivation. A common complication of zoster is postherpetic neuralgia (PHN), a chronic, often debilitating pain condition that can last months or even years. The risk for PHN in patients with zoster is 10%--18%. Another complication of zoster is eye involvement, which occurs in 10%-25% of zoster episodes and can result in prolonged or permanent pain, facial scarring, and loss of vision.

### ***Diagnosis:***

Diagnosis might not be possible in the absence of rash. In its classical manifestation, the signs and symptoms of zoster are usually distinctive enough to make an accurate clinical diagnosis once the rash has appeared. The accuracy of diagnosis is lower for children and younger adults in whom zoster incidence is lower and its symptoms less often classic. Laboratory testing might clarify the diagnosis. Smear test can be used to detect multinucleated giant cells in lesion specimens, but they do not distinguish between infections with VZV and HSV.

### ***Prophylaxis and Treatment:***

Prompt treatment with the oral antiviral agents decreases the severity and duration of acute pain from zoster. Additional pain control can be achieved in certain patients by supplementing antiviral agents with corticosteroids and with analgesics. Established PHN can be managed in certain patients with analgesics, tricyclic antidepressants, and other agents.

The CDC- ACIP recommends routine zoster vaccination with 1 dose for all persons aged  $\geq 60$  years who have no contraindications, including persons who report a previous episode of zoster or who have

chronic medical conditions. Licensed zoster vaccine is a lyophilized preparation of a live, attenuated strain of VZV, the same strain used in the varicella vaccines.

In a large clinical trial, zoster vaccine was partially efficacious at preventing zoster. It also was partially efficacious at reducing the severity and duration of pain and at preventing PHN among those developing zoster.

### **Control Measures:**

- The application of standard and contact precautions, in addition to covering the lesion, may reduce the spread of infection of localized zoster lesions.
- For generalized (disseminated zoster) and localized zoster with an uncontained/uncovered lesion, or localized zoster in immunocompromised patients (until disseminated infection is ruled out), the control measures of varicella (chickenpox) should be followed.
- Immunocompetent DHCP with localized zoster should cover the lesion and avoid contact with susceptible persons at high risk for severe varicella in their household and occupational settings until lesions are dry and crusted.
- For susceptible DHCP who are exposed to localized zoster with a contained/covered lesion, post-exposure vaccine within 120 hours or varicella zoster immunoglobulin (VZIG) within 96 hours should be considered:
  - a. Dental health care personnel who have received 1 dose of vaccine should receive the second dose within 3–5 days after exposure to the rash (provided 4 weeks have elapsed after the first dose). Dental health care personnel who have received 1-2 doses of vaccine should not be excluded from work.
  - b. Susceptible DHCP who have never received doses of varicella vaccine should receive postexposure vaccination as soon as possible. They should also be excluded from work from 8th day after 1st exposure through 21st day (28th day if varicella-zoster immune globulin admin-

istered) after the last exposure to the virus. And if varicella occurs, the work restriction applies until all lesions are dry and crusted or, if only lesions that do not crust (i.e., macules and papules) are present, until no new lesions appear within a 24-hour period.

### ***Epstein-Barr Virus (EBV) [13, 60]***

#### ***Infectious Mononucleosis***

Infectious mononucleosis is generally a disease of adolescents and young adults.

#### ***Causative Microorganism:***

One type of infectious mononucleosis is caused by infection with the EBV.

#### ***Transmission of the Disease:***

The disease is transmitted orally by direct contact with saliva and by droplet. Viruses are excreted through the saliva even when the patient has no symptoms of disease, so there may be a long period of communicability or a lasting carrier state.

#### ***Clinical Features:***

It is characterized by fever, lymphadenopathy, and sore throat and is identified by specific atypical lymphocytes called mononucleosis cells.

#### ***Control Measures:***

The application of standard precautions may reduce the spread of infection

### ***Cytomegalovirus (CMV) Infection [60]***

#### ***Causative Microorganism:***

Cytomegalovirus infections are widespread and appear in various forms. The most severe form develops in infants infected in utero.

#### ***Transmission of the Disease:***

The virus is excreted in urine, saliva, cervical secretions, and se-

men. The virus from the mother's primary or recurrent infection may infect the infant in utero, in the birth canal, or through breast milk. Cytomegalovirus infection in a fetus may lead to a child that is premature, is anemic, and has mental retardation, microcephaly, motor disabilities, deafness, and chronic liver disease.

***High Risk Groups:***

- Blood transfusion
- Transplantation of solid organ and bone marrow.
- Sexual transmission through semen, vaginal fluid, or saliva.
- Children attending day-care centers have a high prevalence of CMV infection (due to spread of respiratory droplet, especially among children).

***Clinical Features:***

Symptomatic infection is relatively rare, but infectious mononucleosis, pneumonitis, and other infections may be caused by CMV. Primary and reactivated infections in immunodeficient or immunosuppressed patients is commonly caused by CMV, which is an opportunistic agent. Infection with CMV is a serious complication of the acquired immunodeficiency syndrome.

***Control Measures:***

The application of standard precautions and personal hygiene (handwashing) may reduce the spread of infection.



## **Other Infectious Diseases of Concern in Dentistry**

### ***Tetanus [4, 6, 13, 27, 63]***

#### ***Causative Microorganism:***

Tetanus is an extremely dangerous and often fatal disease that is caused by spore-forming bacillus found in soil, dust, or animal or human feces.

#### ***Transmission of the Disease:***

This microbe is not transmitted from person to person. It is usually introduced into the body through a wound or break in the skin (as in a puncture wound from a soiled instrument). Health care personnel are not at greater risk for tetanus than the general population.

#### ***Clinical Features:***

The organism causing tetanus produces the severe muscle spasms and rigidity that give the disease its popular name of lockjaw.

#### ***Prophylaxis:***

The disease can be prevented by the administration of a vaccine; however, immunity must be kept current through booster doses (It is important that dental personnel keep all of the immunizations current).

Tetanus immune globulin (TIG) contains antibody to tetanus toxin. It can bind to the toxin and deactivate it. TIG may be administered (in addition to a tetanus booster) to those who are not up-to-date with their tetanus vaccinations.

#### ***Control Measures:***

The application of standard precautions and personal hygiene (handwashing) reduce the spread of infection.

#### ***Management of Exposures to Tetanus:***

- Dental health care personnel younger than age 65 years with direct patient contact should receive a single dose of Tdap if they have not previously received it (see section on Vaccination). After receipt of Tdap, DHCP should receive Td for

routine booster every 10 years.

- In case of puncture wounds or lacerations, previously vaccinated DHCP should receive a Td booster at the time of injury if more than 5 years have elapsed since their last booster. Those with severely or heavily contaminated wounds may require human tetanus immunoglobulin in addition to vaccine if their history of previous primary tetanus immunizations is not definite.

## ***Diphtheria [7, 13, 64]***

### ***Causative Microorganism:***

Diphtheria is a serious bacterial disease caused by *Corynebacterium*. It usually affects the mucosa of the upper respiratory tract, and sometimes the skin. *Corynebacteria* can also produce a powerful exotoxin which is cardiotoxic and neurotoxic.

### ***Transmission of the Disease:***

Transmission is via respiratory droplets and direct person-to-person contact with cutaneous lesions (highly contagious). Patients carry toxigenic organisms up to 3 months after infection.

### ***Clinical Features:***

Respiratory diphtheria presents as a sore throat with low-grade fever and an adherent pseudomembrane of the tonsils, pharynx, or nose. Neck swelling is usually present in severe disease. Nasal diphtheria is often milder than laryngeal diphtheria, which is serious because of respiratory tract obstruction. Myocarditis, polyneuritis, and airway obstruction are common complications of respiratory diphtheria; death occurs in 5%-10% of respiratory cases.

Cutaneous diphtheria presents as infected skin lesions which lack a characteristic appearance. Complications and deaths occur less frequently from cutaneous diphtheria.

### ***Prophylaxis and Treatment:***

The disease can be prevented by the administration of a vaccine; however, immunity must be kept current through booster doses.

Treatment of the disease requires the use of an antitoxin in addition to penicillin or erythromycin.

### ***Control Measures:***

- In addition to standard precautions, droplet precautions (in cases of respiratory diphtheria) and contact precautions (in cases of cutaneous diphtheria) should be applied to reduce the spread of infection.
- Droplet and contact precautions could be terminated when antimicrobial treatment is completed and two cultures taken 24 hours apart shows negative results.
- Dental health care personnel with active diphtheria and exposed DHCP should be excluded from duty until antimicrobial therapy is completed and two cultures taken more than 24 hours apart shows negative results.
- Dental health care personnel younger than age 65 years with direct patient contact should receive a single dose of Tdap if they have not previously received it. After receipt of Tdap, DHCP should receive Td for routine booster every 10 years (see section on Vaccination).

## ***Measles [7, 13, 27]***

### ***Causative Microorganism:***

Measles is a potentially serious disease caused by the rubeola virus.

### ***Transmission of the Disease:***

It is a highly contagious rash illness that is transmitted by respiratory droplets and airborne spread and has an incubation period of 10-12 days. Because of the greater opportunity for exposure, HCP are at higher risk than the general population for becoming infected with measles. A study conducted in 1996 in medical facilities indicated that HCP were 19 times more likely to develop measles than other adults.

### ***Clinical Features:***

The disease is characterized by a characteristic exanthematous rash.

The prodromal symptoms are conjunctivitis, nasal discharge, headache, fever and sore throat. Three to 4 days before the appearance of the rash, patches called Koplik's spots may appear in the oral cavity. These patches are small, irregular in shape, and red with bluish-white specks and are located on the mucosa of the cheeks. The disease is highly contagious at this stage.

Severe complications, which might result in death, include pneumonia and encephalitis.

### ***Prophylaxis:***

Measles can be prevented by the administration of a vaccine. Measles vaccine is administered in combination with the mumps and rubella components as the MMR vaccine. Health care personnel who have an "indeterminate" level of immunity upon testing should be considered non-immune. Nonpregnant, susceptible people exposed to the rubeola virus may receive protection if immunized within 72 hours after exposure.

### ***Control Measures:***

- In addition to standard precautions, airborne precautions should be applied to reduce the spread of infection.
- Airborne precautions may be terminated 4 days after the onset of rashes.
- Susceptible DHCP (not immune) should not treat patients known or suspected to have measles if other immune DHCP are available. If susceptible DHCP must treat patients known or suspected to have measles, DHCP should wear respiratory protection (N95 respirator). DHCP immune to measles need not wear an N95 respirator when dealing with measles patients.
- For exposed DHCP, post-exposure vaccine within 72 hrs or immunoglobulin within 6 days should be provided.
- Dental health care personnel with active measles and exposed DHCP should be excluded from duty from day 5 after first exposure to day 21 after last exposure (exposed personnel) or for 4 days after rash appears (active and exposed personnel), regardless of post-exposure management.

## **Rubella [7, 13, 27, 57]**

### ***Causative Microorganism:***

Rubella, also known as German measles, is a mild viral disease caused by the Rubella Virus.

### ***Transmission of the Disease:***

Rubella virus can be transmitted via droplet and perinatal (through placenta) routes of transmission. During outbreaks, transmission occurred from HCP to susceptible coworkers and patients, as well as from patients to HCP and other patients. Health care personnel may also transmit the disease to associates some of whom might be pregnant. However, no data are available on whether HCP are at increased risk for acquiring rubella compared with other professions.

### ***Clinical Features:***

Rubella is characterized by a slight rash, low-grade fever, lymphadenopathy, and malaise. Although rubella is considered a benign disease, transient arthralgia and arthritis are observed commonly in infected adults, particularly among postpubertal females. Other complications that occur infrequently are thrombocytopenia and encephalitis. Infection is asymptomatic in 25%–50% of cases.

The danger from rubella is to women, particularly during the first trimester of pregnancy. If the mother has rubella, she runs the risk of miscarriages, stillbirths, giving birth to a child who is severely deformed, mentally retarded, deaf, blind, or has congenital heart defects. Fetal infection with rubella (from infected mother) can occur in as many as 80% of fetuses during the first trimester of pregnancy and to some extent in the second trimester.

Clinical diagnosis of rubella is unreliable and should not be considered in assessing immune status.

### ***Prophylaxis:***

Rubella may be prevented by the administration of a vaccine.

Rubella vaccine is administered in combination with the mumps and measles components as the MMR vaccine. Neither rubella-containing

vaccine nor immune globulin (Ig) is effective for postexposure prophylaxis of rubella. Although intramuscular administration of 20 mL of immunoglobulin within 72 hours of rubella exposure might reduce the risk for rubella, but it will not eliminate it.

### ***Control Measures:***

- In addition to standard precautions, droplet precautions should be applied to reduce the spread of infection.
- Droplet precautions may be terminated 7 days after onset of rashes.
- Susceptible DHCP (not immune) should not treat patients known or suspected to have rubella if other immune DHCP are available.
- Pregnant women who are not immune should not treat patients known or suspected to have rubella.
- For exposed DHCP, vaccine should be administered within three days of exposure to non-pregnant susceptible individuals.
- Dental health care personnel with active rubella and exposed DHCP should be excluded from duty from day 7 after first exposure to day 21 after last exposure (exposed personnel) or for 7 days after rash appears (active and exposed personnel), regardless of post-exposure vaccine.

## ***Mumps [7, 13, 27, 65]***

### ***Causative Microorganism:***

Mumps is an acute systemic infection caused by a paramyxovirus.

### ***Transmission of the Disease:***

Mumps virus can be transmitted via droplet and contact routes of transmission. The mean incubation period for mumps is 18 days, and the virus has been isolated from saliva from infected people 7 days before parotitis develops. Mumps can be transmitted before the development of symptoms and the disease is most contagious 1–2 days before the onset of parotitis. Mumps can also be transmitted by people with subclinical infection.

Probability of mumps virus shedding decreases rapidly after the onset of symptoms. However, patients will still be shedding the virus 5-9 days after the onset of symptoms and, thus, may still be contagious during this period.

Although health-care-associated transmission of mumps is infrequent, it might be underreported because of the high percentage (20%–40%) of infected persons who might be asymptomatic. In a survey of 9,299 adults in different professions conducted in 1968, before vaccination was used routinely, the rate of mumps acquisition was highest among dentists and HCP, with rates of 18% among dentists and 15% among physicians.

### ***Clinical Features:***

Mumps is a viral infection that causes inflammation and swelling of the parotid glands and sometimes the submandibular salivary glands. It is accompanied by headache, fever, sore throat, trismus, furred tongue, earache, and pain on chewing and during salivation. The spectrum of illness ranges from subclinical infection (20%–40%) to nonspecific respiratory illness, sialadenitis including classic parotitis, deafness, orchitis, and meningoencephalitis; severity increases with age.

### ***Prophylaxis:***

Mumps can be prevented by the administration of a vaccine.

### ***Control Measures:***

- In addition to standard precautions, droplet precautions should be applied to reduce the spread of infection.
- Droplet precautions may be terminated 5 days after onset of swelling.
- Susceptible DHCP (not immune) should not treat patients known or suspected to have mumps if other immune DHCP are available.
- Dental health care personnel with active mumps and exposed DHCP should be excluded from duty from day 12 after exposure to day 25 after exposure (exposed personnel) or for 5 days after onset of parotitis (active and exposed personnel).

## ***Poliomyelitis [13, 27, 66]***

### ***Causative Microorganism:***

Poliomyelitis (polio) is a highly infectious disease caused by poliovirus, an enterovirus that invades the nervous system.

### ***Transmission of the Disease:***

Polio affects humans only, and it is spread by person-to-person contact (contact transmission) and by fecal-oral route of transmission. Poliovirus can be recovered from infected persons, including from pharyngeal specimens, feces, urine, and (rarely) saliva and cerebrospinal fluid.

### ***High Risk Groups:***

In general, three groups of adults are at higher risk and should consider polio vaccination in the following situations:

1. Persons traveling to polio-endemic or high-risk areas of the world.
2. Health care personnel working in a laboratory and handling specimens that might contain polioviruses.
3. Health care personnel treating patients who could have polio or have close contact with a person who could be infected with poliovirus.

### ***Clinical Features:***

It is potentially fatal disease that can strike at any age.

Approximately 95% of persons infected with polio will have no symptoms. About 4-8% of infected persons have minor symptoms, such as fever, fatigue, nausea, headache, flu-like symptoms, stiffness in the neck and back, and pain in the limbs, which often resolve completely. Less than 1% of polio cases result in permanent paralysis of the limbs (usually the legs). Of those paralyzed, 5-10% die when the paralysis strikes the respiratory muscles. The death rate increases with increasing age.

### ***Prophylaxis and Treatment:***

There is no cure, but there are safe and effective vaccines. Therefore, the strategy to eradicate polio is based on preventing infection by



immunizing every child to stop transmission.

### ***Control Measures:***

In addition to standard precautions, contact precautions should be applied to reduce the spread of infection.

## ***Syphilis [4, 7, 13, 22, 67]***

### ***Causative Microorganism:***

Syphilis is caused by *Treponema pallidum* spirochetes.

### ***Transmission of the Disease:***

Syphilis is a sexually transmitted disease that can also be transmitted through any other **direct** contact with a syphilis sore and through perinatal routes (placenta). Sores occur mainly on the external genitals, vagina, anus, or in the rectum. Sores also can occur on the lips and in the mouth. Syphilis cannot be transmitted by indirect contact because *Treponema pallidum* spirochetes are quite fragile outside the body. In the dental operator, the danger of cross-infection is through contact with oral lesions.

Although transmission occurs from persons with sores who are in the primary or secondary stage, many of these sores are unrecognized. Thus, transmission may occur from persons who are unaware of their infection.

### ***Clinical Features:***

Syphilis may be asymptomatic. However, if not treated, persons infected with syphilis remain at risk for developing late stage complications.

The **first stage** of syphilis is the presence (at the inoculation site of spirochaete) of a painless flat, red, indurated ulcer with serous exudate, known as a chancre, which is highly infectious on contact. When it occurs on the lip, it may resemble herpes, but the crusting is darker. The time between infection with syphilis and the start of the first symptom can range from 10 to 90 days (average 21 days). The chancre lasts 3 to 6 weeks, and it heals without treatment. However, if adequate treatment is not administered, the infection progresses to the secondary stage.

The **second stage** is characterized by skin rash and mucous membrane lesions. This stage is also infectious, and immediate infection may occur through contact with an open sore. The rash can appear as the chancre is healing or several weeks after the chancre has healed. The characteristic rash of secondary syphilis may appear as rough, red, or reddish brown spots (oozing sores) both on the palms of the hands and the bottoms of the feet. Sometimes rashes associated with secondary syphilis are so faint that they are not noticed. In addition to rashes, symptoms of secondary syphilis may include fever, swollen lymph glands, sore throat, patchy hair loss, headaches, weight loss, muscle aches, and fatigue. Signs of special interest to dental personnel are:

1. Split papules at the corners of the mouth.
2. Grayish-white, moist, so-called mucous patches on the tongue, tonsils or inner surfaces of the lips (these are highly infectious).

The signs and symptoms of secondary syphilis will resolve with or without treatment, but without treatment, the infection will progress to the latent and possibly late stages of disease.

The **third stage**, is usually fatal, and it may occur after the disease has been dormant for 20 years. In this late stage of syphilis, the disease may damage the internal organs, including the brain, nerves, eyes, heart, blood vessels, liver, bones, and joints. Signs and symptoms of the late stage of syphilis include difficulty coordinating muscle movements, paralysis, numbness, gradual blindness, and dementia. Gumma nodules may form on the palate lips or tongue. A pattern of ulceration and healing of the hard palate may eventually lead to perforation.

### ***Diagnosis:***

*Treponema pallidum* cannot be cultured in vitro. However, a serological test to detect specific antibodies can be used to diagnose syphilis. Dark ground microscopy of tissue fluid from primary and secondary clinical lesions helps in identifying the microorganism.

### ***Prophylaxis and Treatment:***

Syphilis is easy to cure in its early stages. A single intramuscular in-

jection of penicillin, an antibiotic, will cure a person who has had syphilis for less than a year. Additional doses are needed to treat someone who has had syphilis for longer than a year. For people who are allergic to penicillin, other antibiotics are available to treat syphilis. Treatment will kill the syphilis bacterium and prevent further damage, but it will not repair damage already done.

Having syphilis once does not protect a person from getting it again. Following successful treatment, people can still be susceptible to re-infection.

### ***Control Measures:***

- The application of standard precautions reduce the spread of infection
- **Dental Health Care Personnel:**
  - For infection control purposes, pre-employment evaluation including serologic tests for syphilis must be performed.
  - Non-Saudi staff will be screened for syphilis before recruitment and travelling to the Kingdom and again on arrival.
  - According to a Saudi Arabian Ministry of Health Regulation, applicants who have established syphilis infection will be considered as non fit to work.

## ***Meningitis [13, 27, 68-70]***

### ***Causative Microorganism:***

Meningitis is a disease caused by the inflammation of the protective membranes covering the brain and spinal cord (“meninges”). The inflammation is usually caused by an infection of the fluid surrounding the brain and spinal cord.

Viral infections are the most common cause of meningitis; bacterial infections are the second most common cause. Other, rarer, causes of meningitis include fungi, parasites, and non-infectious causes, including physical injury, certain diseases like AIDS, cancer, diabetes, or

certain drugs that weaken the body's immune system.

For bacterial meningitis, it is important to know which type of bacteria is causing the disease because antibiotics can prevent some types from spreading and infecting other people. Before the 1990s, *Haemophilus influenzae* type b (Hib) was the leading cause of bacterial meningitis. Meningitis caused by Hib occurs mostly in children under the age of 5 years.

Hib vaccine is given to all children as part of their routine immunizations. This vaccine has reduced the number of cases of Hib infection and the number of related meningitis cases. Today, *Streptococcus pneumoniae* and *Neisseria meningitidis* are the leading causes of bacterial meningitis. Meningitis in individuals at the extremes of age, infants, young children and the elderly, is commonly caused by *S. pneumoniae*.

During epidemics, children and young adults are most commonly affected. The highest rates of endemic or sporadic disease occur in children less than 2 years of age.

Different viral infections can lead to viral meningitis, but most cases are caused by enteroviruses (which include enteroviruses, coxsackieviruses, and echoviruses). The incubation period is usually between 3 and 7 days for enteroviruses. Other viral infections that can lead to meningitis include mumps, herpesvirus (such as Epstein-Barr virus, herpes simplex viruses, and varicella-zoster virus), measles, and influenza. Arboviruses, which mosquitoes and other insects spread, can also cause infections that can lead to viral meningitis. Lymphocytic choriomeningitis virus, which is spread by rodents, is a rare cause of viral meningitis.

The incubation period of meningococcal disease is 3 to 4 days, with a range of 2 to 10 days.

### ***Transmission of the Disease:***

Some forms of bacterial meningitis are contagious. *Haemophilus influenzae*, *Streptococcus pneumoniae* and *Neisseria meningitidis* are respiratory pathogens and can mainly be spread from person to per-

son through the exchange of respiratory and throat secretions (droplets and contact transmission). This can occur through coughing, kissing, and sneezing.

Following acquisition of bacterial meningitis, illness results when the organism is able to colonize the mucosa of the nasopharynx and oropharynx and enters the blood stream. Subsequently the organism gains access to the cerebrospinal fluid, where infection is established and inflammation occurs.

People in the same household or daycare center, or anyone with direct contact with a patient's oral secretions would be considered at increased risk of getting the infection. People at high risk should receive prophylactic antibiotics to prevent them from getting the disease.

Viral meningitis is also contagious. The viruses that most often cause viral meningitis are spread from person to person through fecal contamination (such as by someone who uses the toilet or changes a baby's diaper and does not wash her/his hands well afterward).

Infection may also be transmitted from patient to HCP and from HCP to patient during the blood-taking procedure.

### ***Clinical Features:***

Often, the symptoms of viral meningitis and bacterial meningitis are the same. Sudden onset of high fever, headache, and stiff neck are common symptoms of meningitis in anyone over the age of 2 years. These symptoms can develop over several hours, or they may take 1 to 2 days. Other symptoms may include nausea, vomiting, photophobia (sensitivity to bright light), altered mental status, lack of appetite and sleepiness. Infants with meningitis may appear slow or inactive, have vomiting, be irritable, or be feeding poorly. As the disease progresses, patients of any age may have seizures.

Viral (sometimes called "aseptic") meningitis is serious but rarely fatal in people with normal immune systems. Usually, the symptoms last from 7 to 10 days and the patient recovers completely.

Bacterial meningitis, on the other hand, can be very serious and may result in brain damage, hearing loss, or learning disabilities if not

treated promptly. Fatality rates vary with age at the time of illness and the species of bacterium causing infection, but typically range from 3 to 19% in developed countries. Higher case-fatality rates (37-60%) have been reported in developing countries. Up to 54% of survivors are left with disability due to bacterial meningitis, including deafness, mental retardation, and neurological sequelae.

### ***Diagnosis:***

Early diagnosis and treatment are very important. The diagnosis is usually made by laboratory tests of a patient's spinal fluid. The test can reveal whether the patient is infected with a virus or a bacterium. However, blood test can be done when collecting patient's spinal fluid is contraindicated, cannot be performed for technical reasons, or when bacteremia is suspected.

If bacteria are present, they can be grown (cultured) to identify the specific type of bacteria that is causing the infection and to select the proper antibiotic.

The specific causes of viral meningitis may be determined by tests used to identify the virus in samples collected from the patient. However, identifying the exact virus causing meningitis may be difficult.

### ***Prophylaxis and Treatment:***

Bacterial meningitis can be treated with a number of effective antibiotics. It is important, however, that treatment be started early in the course of the disease. Appropriate antibiotic treatment of most common types of bacterial meningitis can prevent severe illness, reduce the spread of infection from person to person and reduce the mortality to below 15%, although the risk is higher among the elderly.

There is no specific treatment for viral meningitis. Most patients completely recover on their own within 2 weeks. Doctors often will recommend bed rest, plenty of fluids, and medicine to relieve fever and headache.

There are vaccines against Hib, against some serogroups of *N. meningitidis* and many types of *Streptococcus pneumoniae*. The vaccines are safe and highly effective.

### **Control Measures:**

- In addition to standard precautions, droplet precautions should be applied to reduce the spread of infection.
- Postexposure prophylaxis is advised for all persons who have had intensive, unprotected contact (i.e., without wearing a mask) with infected patients (e.g., via mouth-to-mouth resuscitation, endotracheal intubation, or endotracheal tube management), including HCP who have been vaccinated.
- Antimicrobial prophylaxis can eradicate carriage of *N. meningitidis* and prevent infections in persons who have unprotected exposure to patients with meningococcal infections.
- Antimicrobial prophylaxis (Rifampicin 600 mg twice a day for 2 days, Ciprofloxacin 500 mg orally as a single dose or Ceftriaxone 250 mg IM single dose) are effective in eradicating nasopharyngeal carriage of *N. meningitidis* and should be offered immediately to personnel who have had intensive direct contact with an infected patient without using proper precautions.
- Postexposure prophylaxis should be administered within 24 hours of exposure when feasible; postexposure prophylaxis administered >14 days after exposure is of limited or no value.

### ***Methicillin-Resistant Staphylococcus Aureus*** **[13-14, 19]**

Staphylococcal infection or carriage occurs frequently in humans. There are two sources of nosocomial transmission; persons with lesions and asymptomatic carriers. The anterior nares are one of the most commonly colonized sites, but carriage of *S. aureus* may occur at other sites (e.g., draining or crusted lesion, nasopharynx and oropharynx, and the skin of the axilla, fingers, and perineum). Outbreaks of methicillin-resistant-staphylococci tend to occur more frequently in intensive care and burn units.

### **Causative Microorganism:**

Multidrug-resistant organisms (MDROs) are defined as microorganisms, predominantly bacteria, that are resistant to one or more classes

of antimicrobial agents. Such organisms, including methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE) and certain gram-negative bacilli (GNB), have important infection control implications.

*Staphylococcus aureus* is a gram-positive coccus that frequently colonizes the nose and skin of healthy people, and it can cause a variety of localized and invasive syndromes, ranging from superficial skin infections to life-threatening pneumonia and bloodstream infections. MRSA refers to *S. aureus* that is resistant to all currently available  $\beta$ -lactam antimicrobial agents, including antistaphylococcal penicillins (methicillin, oxacillin, nafcillin) and cephalosporins. In health care settings, MRSA frequently affects people with chronic illness, frequently causes invasive disease, and resists multiple classes of antimicrobial agents. While, in the community, MRSA frequently affects young, otherwise healthy people, and predominantly causes skin and soft-tissue infection and it is susceptible to most classes of antimicrobial agents other than  $\beta$ -lactams.

### ***Transmission of the Disease:***

In the community, outbreaks of MRSA infections have been reported in settings in which people are crowded, have frequent skin-to-skin contact, have compromised skin (cuts and abrasions), lack adequate hygiene practices, and share personal items. Draining lesions are highly infectious and represent the most common source of transmission.

In health care settings, *S. aureus* most often is spread indirectly from person to person on the transiently contaminated hands. MRSA has been isolated from environmental surfaces in health care facilities, but contaminated environmental surfaces and objects likely play a relatively minor role in MRSA transmission. Frequent exposure to antimicrobial agents may facilitate acquisition of MRSA.

### ***Risk in the Dental Operatory:***

In a study of *S. aureus* in a dental school clinic, investigators isolated MRSA from samples collected from the emergency treatment area: dental chair push buttons, light handles, air-and-water syringes and a



computer keyboard. MRSA has also been found in the oral cavity and on dentures, more frequently in elderly people. A risk factor for oral carriage of MRSA among older people is related to antibiotic use, low serum albumin levels, and poor nutrition.

There has been one documented transmission of MRSA from a British dental practitioner to patients. Two patients undergoing oral surgical procedures within three weeks of each other developed MRSA infections of the same type. The dentist was identified as the only staff member with the same type of MRSA isolated from his fingers and nares.

### ***Clinical Features:***

Health care–associated MRSA infections most commonly manifest as surgical site infections, pneumonia or bloodstream infections, and they require treatment with systemic antimicrobial agents.

About 77 percent of community-associated MRSA infections are localized in the skin in the form of pustules, boils or abscesses and typically can be treated in outpatient settings, often without antibiotics. However, less frequently, community strains of MRSA can lead to severe infections and potentially to invasive disease that can be fatal.

### ***Treatment and Prophylaxis:***

Vancomycin remains an agent of choice for treatment of invasive MRSA infections. However, increased use of vancomycin has contributed to a rapid increase in the incidence of colonization and infection with vancomycin-resistant enterococci. Coexistence of vancomycin-resistant enterococci and MRSA in the same host was shown to facilitate the transfer of vancomycin resistance to *S. aureus*. Antimicrobial treatment options exist for vancomycin resistant *S. aureus* infections but are limited.

No *S. aureus* vaccines are available, although such products are being developed.

### ***Control Measures:***

- The CDC's Healthcare Infection Control Practices Advisory Committee developed measures to control the spread of mul-

drug-resistant organisms (MDROs) of epidemiologic importance, such as MRSA, in health care settings.

- Prevention of MRSA and other MDRO transmission in these settings requires a comprehensive strategy that includes administrative measures such as:
  1. Use of standard precautions for all patients.
  2. Use of contact precautions for patients known to be infected or colonized with these organisms.
  3. Implement systems to designate patients known to be colonized or infected with MDRO and to notify receiving healthcare facilities and personnel prior to transfer of such patients within or between facilities.
  4. Provide education and training on risks and prevention of MDRO transmission during orientation and periodic educational updates for DHCP.
  5. Judicious use of antimicrobial agents.
  6. Ongoing monitoring of trends through time to measure progress in prevention and control.
- Few studies have been conducted to determine whether any additional actions can improve prevention of MRSA in dental settings: Investigators in one such study described the elimination of MRSA from patients' dentures by use of common denture-cleansing solutions, and researchers in another study found that the rate of bacteremia occurring within one hour after a tooth extraction can be reduced by means of a preoperative rinse with an oral chlorhexidine solution.
- Infected persons should be restricted from work if wound drainage cannot be contained.

### ***Creutzfeldt-Jakob Disease (CJD) and Other Prion Diseases*** ***[10, 71-73]***

Classic CJD is a human prion disease. It is a neurodegenerative disorder with characteristic clinical and diagnostic features. The most common form of classic CJD is believed to occur sporadically, caused

by the spontaneous transformation of normal prion proteins into abnormal prions.

Classic CJD has been recognized since the early 1920s. This disease occurs worldwide, at a rate of approximately one case per 1 million populations per year, although rates of up to two cases per million are not unusual. The risk of CJD increases with age, and in persons aged over 50 years of age, the annual rate is approximately 3.4 cases per million.

Variant Creutzfeldt-Jakob disease (vCJD) is a very rare, degenerative, fatal disease that can infect persons for many years before making them sick by destroying brain cells.

### ***Epidemiology:***

Since variant CJD was first reported in 1996, a total of 217 patients (as of October 2009) with this disease from 11 countries have been identified (including one case from Saudi Arabia). This variant form of CJD should not be confused with the classic form of CJD that is endemic throughout the world.

Both vCJD and CJD cause progressive degeneration of the brain leading to death. However, the variant form usually affects persons much younger than other forms of CJD.

### ***Transmission of the Disease:***

Eating beef and beef products contaminated with the infectious agent of bovine spongiform encephalopathy (BSE) is the main cause of vCJD. Although experience with this new disease is limited, evidence to date indicates that there has never been a case of vCJD transmitted through direct contact of one person with another. A case of probable transmission of vCJD through transfusion of blood components from an asymptomatic donor who subsequently developed the disease has been reported.

Potential infectivity of oral tissues in CJD or vCJD patients is an unresolved issue. Scientific data indicate the risk, if any, of sporadic CJD transmission during dental and oral surgical procedures is low to nil.

### ***Clinical Features:***

Classic CJD is rapidly progressive and always fatal (usually within 1 year of onset of illness), whereas variant CJD has a longer survival after onset of illness (the majority of illnesses lasting more than one year).

The median age at death for vCJD patients is 28 years, compared with 68 years for patients with classic CJD. The median duration of illness for vCJD is 14 months, compared to 5 months for classic CJD.

Variant CJD also has somewhat different clinical symptoms than classic CJD. Classic CJD is characterized by dementia and early neurologic signs whereas vCJD is characterized by prominent psychiatric/behavioral symptoms; painful dyesthesia and delayed neurologic signs.

### ***Diagnosis:***

Using brain biopsy, variant CJD produces a characteristic abnormality in brain tissue called florid plaques; rounded deposits of abnormal proteins surrounded by vacuoles, rarely if ever seen in the other forms.

### ***Control Measures:***

No recommendation is offered by CDC regarding use of special precautions in addition to standard precautions when treating known CJD or vCJD patients.

# VACCINATION

## The Immune System [4, 6, 74]

The immune system plays an extremely important role in the ability of the body to resist pathogens. Immunity is a condition of an organism that allows it to successfully resist a specific infection. An individual who produces a large number of antibodies against a bacterium is said to be resistant, or immune, to infection from that bacterium. There are two main categories of immunity: **inherited** and **acquired**.

- **Inherited immunity** is immunity with which a person is born.
- **Acquired immunity** is immunity that is developed during person's life time. It is subdivided into two groups: naturally acquired immunity is obtained naturally, and artificially acquired immunity is obtained through vaccination.

### ***Naturally Acquired Immunity***

#### ***1. Active Immunity:***

When the body was fighting the invading pathogen it formed antibodies that provide future resistance against that particular pathogen.

#### ***2. Passive Immunity:***

Occur during pregnancy or breastfeeding when the fetus or infant receives antibodies from the mother.

### ***Artificially Acquired Immunity***

Artificially acquired immunity could be obtained through:

#### ***1. Active immunization:***

Use of an antigen substance to induce immunity by stimulating an immune response:

- **Vaccine:** A suspension of live (usually attenuated) or inactivated microorganisms, or fractions thereof.
- **Toxoid:** A modified (nontoxic) bacterial toxin that is capable of

stimulating antitoxin formation.

## 2. *Passive immunization*

Use of an antibody containing preparation to prevent onset of infection.

- Immune globulin (Ig): A sterile solution containing antibodies from human blood.
- Antitoxin: A solution of antibodies derived from the serum of animals immunized with specific antigens.

## Vaccination

A vaccine contains weakened disease causing organisms or genetically engineered organisms. Harmful characteristic of the disease producing organisms are eliminated from the vaccine to make them less likely to cause the disease. The body then produces antibodies in response to the vaccine.

Vaccines may be one of the following types:

1. Monovalent: A vaccine consisting of a single strain or type of organism.
2. Bivalent: A vaccine consisting of a two strains or types of organism.
3. Trivalent: A vaccine consisting of three types of strains of a single organism (influenza vaccine) or three different organisms (DPT vaccine).
4. Polyvalent: Multiple strains or types of organisms in the vaccine (23-valent pneumococcal vaccine).

It is extremely important that dental healthcare workers be immunized against vaccine-preventable diseases. After a period of time, the number of antibodies against a particular antigen may decrease. A booster is an additional dose of vaccine administered to increase the number of antibodies.

## **Immunization of Dental Health Care Personnel** **[6, 13, 25, 29, 74-75]**

Maintenance of immunity is an important part of disease prevention and infection control in dental offices and hospital-based oral health programs. Optimal use of immunizing agents will safeguard the health of DHCP, obviate unnecessary work restrictions, and protect patients from becoming infected by DHCP.

Although there is a chance that dentists can infect their patients, dentists are at a greater risk for contracting diseases from their patients than patients are from their dentists. Indications for use of recommended routine vaccines are generally the same for DHCP as for the general population; however, immunity to some diseases, such as hepatitis B, may be more important for DHCP.

Although the OSHA bloodborne pathogens standard focuses on HBV and HIV infection, there are many other infectious diseases that can cause HCP devastating or fatal illness. Childhood diseases, sexually transmitted diseases, and tuberculosis are but a few of these infectious diseases. Therefore, any HCP who has patient contact or contact with infectious materials should be sure they have had these diseases or have been vaccinated against them.

The ACIP recommends for HCP immunoprophylaxis for hepatitis B, influenza, measles, mumps, rubella, tetanus, diphtheria, pertussis and varicella. There are other diseases, such as tuberculosis, for which immunization of DHCP may or may not be indicated based on special health care delivery situations. Meningococcal disease is another disorder characterized by the ACIP as possibly indicated for immunization of HCP in special circumstances. Transmission of *Neisseria meningitidis* in the health care delivery settings is rare. Dentists might be at risk for contracting *Neisseria meningitidis* because they are usually in close proximity to the oropharynx of patients.

A history of immunization should be obtained carefully from DHCP at the time of initial employment. This history should be updated periodically. Health care institutions should provide all recommended vaccines for all DHCP (Table 7). Each time a DHCP receives a dose of

vaccine, a notation should be made in the medical record on a special immunization form. The information recorded should include the type of vaccine; the dose, route, and site of administration; the name of the person who gave the vaccine; the date the vaccine was given; the manufacturer and lot number; and the date the next dose is due.

### ***Hepatitis B Vaccine*** ***[4, 6-7, 21-22, 27]***

#### ***Plasma-Derived Vaccine:***

Approximately 5.6 million people worldwide received the plasma-derived vaccine before it was discontinued in 1989.

#### ***Organism:***

A 1:10 dilution of hepatitis B infective serum (strain MS-2) lost infectivity but retained its antigenicity when boiled for 1 minute.

#### ***Administration:***

The vaccine is given in three separate intramuscular injections; the first two doses are administered 1 month apart and the third dose is given 6 months after the first dose.

#### ***Protection:***

After the first dose, approximately 30% of normal, healthy, young adult vaccine recipients respond by the formation of antibodies. The response rate increases to 75% after the second dose, rising to a current response rate 90% to 95% after the third dose.

Continued clinical monitoring of vaccine recipients by the CDC through 1984 and current monitoring by the Food and Drug Administration (FDA) indicate that there is no increased incidence of any severe side effects associated with the hepatitis B vaccine.

#### ***Recombinant DNA Vaccines:***

In July 1986 the first vaccine made using recombinant DNA technology was licensed.



### *Organism:*

The surface antigen of the hepatitis B virus, HBsAg, manufactured in yeasts by genetic recombination and absorbed on to aluminium salt. Successful vaccination also offers protection against delta hepatitis (hepatitis D).

### *Administration:*

Three doses (two doses at an interval of 1 month, followed by a third 6 months later) intramuscularly in the deltoid not in the fatty tissue.

### *Protection and Safety:*

- **Post-testing:**

Post-vaccination testing for the anti-HBV antibodies is recommended. Serologic testing within 6 months of completing the primary series will differentiate people who respond to vaccine from those who fail to respond; however, the results of testing performed more than 6 months after completion of the primary series are more difficult to interpret. Therefore, post-testing should be scheduled soon after the last inoculation, preferably within 1-2 months. The formation of antibodies indicates that the individual has developed immunity.

The 3-dose vaccine series administered intramuscularly at 0, 1, and 6 months produces a protective antibody response in approximately 30%–55% of healthy adults aged  $\leq 40$  years after the first dose, 75% after the second dose, and  $>90\%$  after the third dose. After age 40 years,  $<90\%$  of persons vaccinated with 3 doses have a protective antibody response, and by age 60 years, protective levels of antibody develop in approximately 75% of vaccinated persons.

- **Nonresponders:**

Individuals who have been vaccinated but do not develop antibodies are known as nonresponders. A vaccine recipient who has negative results for anti-HBs several years after vaccination can also be a primary nonresponder who remains susceptible to HBV or a vaccine responder whose antibody levels have decreased below detectability yet he or she is still protected against clinical disease. The three-dose

series should be repeated for nonresponders.

Among nonresponders, 25%–50% respond to an additional vaccine dose, and 44%–100% respond to a 3-dose revaccination series. Persons who do not have protective levels of anti-HBs 1–2 months after revaccination either are infected with HBV or can be considered primary nonresponders. For the latter group, genetic factors might be associated with nonresponse to hepatitis B vaccination. The ACIP does not recommend more than two vaccine series in nonresponders.

Smoking, obesity, genetic factors, and immune suppression are associated with diminished immune response to hepatitis B vaccination.

- **Antibody Persistence and Booster Dose:**

There is controversy over the necessity for booster doses. Some advocate boosters after 3 – 5 years, whereas others, contend that booster doses are unnecessary because of the anamnestic response of the immune system (renewed rapid production of an antibody on the second (or subsequent) encounter with the same antigen).

Ongoing studies have shown that immunological memory in persons who have responded to vaccination with >10 U/mL of anti-HBs lasts for at least 23 years, and probably much longer. People who had demonstrable anti-HBs when initially tested, yet lost detectable anti-HBs on a subsequent blood test, have demonstrated a secondary anamnestic response that was protective against clinical infection when challenged with HBV.

According to the CDC, it is not necessary to test routinely for anti-HBs each year after vaccination.

- Hepatitis B vaccines have been demonstrated to be safe when administered to infants, children, adolescents, and adults. These vaccines are considered safe for pregnant women.

***Recommendation by ACIP 2011:***

- HCP and trainees in certain populations at high risk for chronic hepatitis B (e.g., those born in countries with high and intermediate endemicity) should be tested for HBsAg and anti-HBc/

anti-HBs to determine infection status.

- Hepatitis B vaccine is strongly recommended for all health-care personnel who are occupationally exposed to blood or other potentially infectious materials (2 doses 4 weeks apart; third dose 5 months after second; booster doses not necessary; all doses should be administered IM in the deltoid).
- Postvaccination testing for antibody to hepatitis B surface antigen (anti-HBs) response is indicated for HCP who have blood or patient contact and are at ongoing risk for injuries with sharp instruments or needlesticks including DHCP. This will aid in determining appropriate postexposure prophylaxis.
- Periodic serologic testing to monitor antibody concentrations after completion of the three-dose series is not recommended.
- For postexposure prophylaxis, 0.06 mL/kg Hepatitis B immunoglobulin is given IM as soon as possible after exposure.

### ***Measles-Mumps-Rubella (MMR) Vaccine*** ***[6-7, 13, 22, 27, 74]***

#### ***Organisms:***

Live-attenuated strains of measles, mumps and rubella viruses.

#### ***Administration:***

- Two doses subcutaneous 28 days apart.
- Universal immunization against rubeola (Measles) is recommended (two doses) for all young adults particularly HCP born after 1956.
- Universal immunization against the rubella virus generally is recommended (one dose) for all HCP, but particularly for previously nonimmunized women of childbearing age who do not have laboratory evidence of immunity.
- Immunization against mumps viruses is also recommended (two doses) for health care workers because they are likely to be exposed to mumps and experience the consequences of

infection, characterized by the involvement of major salivary glands, possibly meningitis.

- The vaccine is usually administered in combination form (Measles-mumps-rubella-MMR vaccine).
- Adequate rubella vaccination for HCP consists of 1 dose of MMR vaccine. However, because of the 2-dose vaccination requirements for measles and mumps, the use of the combined MMR vaccine will result in the majority of HCP receiving 2 doses of rubella-containing vaccine, which should provide an additional safeguard against primary rubella vaccine failure.
- Women should receive the vaccine only if they are not pregnant and must be counseled not to become pregnant for 3 months after immunization.
- It is safe to give rubeola vaccine to a person who is already immune, either from natural infection or previous vaccination.
- In approximately 5% to 15% of Rubeola vaccine recipients, symptoms of attenuated measles, characterized by fever, begin to develop 5 to 12 days after vaccination. A transient rash may occur in approximately 5% of vaccinated patients
- Reactions to the mump vaccine are rare. MMR vaccine has 1-dose vaccine effectiveness in preventing mumps of 80%–85% and a 2-dose vaccine effectiveness of 79%–95%.
- The most common complication with rubella vaccine is joint pain, usually of the small distal joints, reported by as many as 40% of adult vaccine recipients.

### ***Protection and Safety:***

- Protection is good and booster is not needed. Two doses of live measles vaccine are considered to provide long-lasting immunity
- MMR vaccine is highly effective in preventing measles with a 1-dose vaccine effectiveness of 95% when administered on or after age 12 months and a 2-dose vaccine effectiveness of 99%.
- Although antibody levels decline following vaccination, a study

examining antibody levels up to 10 years following the second dose of MMR vaccine in children indicates that antibodies remain above the level considered protective.

- MMR vaccine has 1-dose vaccine effectiveness in preventing mumps of 80%–85% and a 2-dose vaccine effectiveness of 79%–95%.
- MMR vaccine is also highly effective in preventing rubella with vaccine effectiveness of >99%.
- Fever can occur in up to 15% of recipients and transient rashes occur in up to 5% of recipients.
- Adolescents and adult women appeared at increased risk of developing arthralgias and arthritis after rubella immunization. The risk is small and generally of short duration. Chronic arthritis has been rarely reported.
- Peripheral neuritis of short duration have also been reported with rubella immunization
- Rare cases of optic neuritis, encephalitis, viral meningitis, parotitis and orchitis were reported following mumps immunization.

**Recommendation by ACIP 2011:**

- All persons who work in health-care facilities should have evidence of immunity to measles, mumps and rubella. This information should be documented and readily available at the work location.
- Evidence of immunity to measles, mumps and rubella for persons who work in health-care facilities includes any of the following:
  - a. written documentation of vaccination with 2 doses of live measles and mumps and 1 dose of live rubella, or 2 doses of MMR vaccine (the two doses administered at least 28 days apart),
  - a. laboratory evidence of immunity,
  - b. laboratory confirmation of disease, or

- c. birth before 1957 (presumed immune from natural disease in childhood).
- Note: Although birth before 1957 generally is considered acceptable evidence of measles, mumps, and rubella immunity, a dose of MMR vaccine is recommended (two doses during a mumps outbreak) to unvaccinated HCP born before 1957.

### ***Influenza Vaccine*** **[6-7, 12-13, 22, 27, 74]**

#### ***Organism:***

Usually contains strains of influenza viruses that are antigenically equivalent to one influenza A (H3N2) virus, another influenza A (H1N1) virus, and one influenza B virus. Because of the phenomenon of the antigenic 'drift' and 'shift' seen in influenza viruses, the vaccine composition needs to be reviewed and altered each year.

#### ***Administration:***

- One dose by injection, repeated each winter, which is the usual period of outbreak.
- Adult immunization with the influenza virus vaccine consists of one 0.5-ml intramuscular dose of vaccine.
- It is strongly recommended for health care providers to minimize the transmission of influenza from health care providers to patients and reduce time lost from work.
- Annual immunization is recommended, particularly for health care providers with diabetes and other metabolic diseases; providers with severe anemia, hemoglobinopathies, or immunosuppression; providers with chronic pulmonary, cardiovascular, or renal disease; providers older than 65 years of age; and all other health care providers who may have contact with high-risk patients (such as neonates, infants, elderly, patients with chronic underlying illness, or immunocompromised patients).
- Two types of influenza vaccines are available: trivalent (Inactivated) influenza vaccine (TIV), which may be given to any HCP; and live attenuated influenza vaccine (LAIV), which may

be given to any non-pregnant healthy HCP age 49 years and younger.

***Protection and Safety:***

- Effectiveness of influenza vaccines varies from year to year and depends on the age and health status of the person getting the vaccine and the similarity or “match” between the viruses or virus in the vaccine and those in circulation.
- The protection is relatively short (approximately one year). Annual vaccination is recommended because the predominant circulating influenza viruses typically change from season to season and, because immunity declines postvaccination with time.
- The vaccine is generally safe and cannot cause influenza.
- The most frequent side effect of vaccination is mild soreness at the vaccination site (affecting 10%–64% of patients) which lasts for less than 2 days. Malaise and low grade fever for as long as 48 hours are infrequent, and hypersensitivity reactions are rare.
- A history of Guillain-Barré syndrome (an acute polyneuropathy, a disorder affecting the peripheral nervous system causing ascending paralysis, weakness, change in sensation or dysfunction of the autonomic nervous system) within 6 weeks following a previous dose of influenza vaccine is considered to be a precaution for use of influenza vaccines.

***Recommendation by ACIP 2011:***

- All HCP who have no contraindications, not just those with direct patient care duties, should receive an annual influenza vaccination.
- Vaccination with the current season’s formulation is recommended.
- Influenza vaccination rates among HCP within facilities should be measured and reported regularly.
- When vaccine supply is limited, HCP should be among the groups considered for prioritized receipt of influenza vaccines.

## ***Diphtheria-Tetanus-Pertussis (DTP)*** **[6-7, 22, 27, 74, 76]**

### ***Organism:***

This vaccine is a three-in-one vaccine for prevention against diphtheria caused by *Corynebacterium diphtheriae*, whooping cough caused by *Bordetella pertussis* and tetanus caused by *Clostridium tetani*. The vaccine contains killed *Bordetella pertussis* (acellular pertussis) and diphtheria and tetanus toxoid.

There are four combination vaccines: DTaP, Tdap, DT, and Td. Two of these (DTaP and DT) are given to children younger than 7 years of age, and two (Tdap and Td) are given to older children and adults. DT does not contain acellular pertussis, and is used as a substitute for DTaP for children who cannot tolerate pertussis vaccine. Td is a tetanus-diphtheria vaccine given to adolescents and adults as a booster shot every 10 years, or after an exposure to tetanus. Tdap is similar to Td but also containing protection against pertussis.

Adult preparations have less diphtheria toxoid component compared to pediatric preparations.

### ***Administration:***

- Five spaced doses of DTaP by intra-muscular injection for infants and children, one dose at each of the following ages: 2, 4, 6, and 15-18 months and 4-6 years. For children who receive DT as a substitute for DTaP, because they cannot tolerate the pertussis vaccine, subsequent booster doses of diphtheria and tetanus toxoids is needed.
- Health care providers not previously immunized should receive a series of two doses of tetanus-diphtheria (Td) vaccine 4 to 8 weeks apart, followed by a booster 6 to 12 months later. Subsequent to the primary series of immunizations, a Td (Tetanus-Diphtheria) booster should be administered every 10 years.
- Adolescents 11-18 years of age (preferably at age 11-12 years) and adults 19 through 64 years of age should receive a single dose of Tdap. For adults 65 and older who have close con-



tact with an infant and have not previously received Tdap, one dose should be received. Tdap should also be given to 7-10 year olds who are not fully immunized against pertussis. Tdap can be given no matter when Td was last received.

- Previously vaccinated health care providers with puncture wounds or lacerations should receive a Td booster if more than 5 years have elapsed since their last booster. Those with severely or heavily contaminated wounds may require human tetanus immunoglobulin in addition to vaccine if their history of previous primary tetanus immunizations is not definite.
- If boosters are given too often, tetanus toxoid can cause severe local pain and swelling.

### ***Protection:***

- Estimated vaccine efficacy is 92%
- Duration of immunity from vaccination has yet to be evaluated.
- Data from many studies support the safety of Tdap in adolescents and adults.
- Booster doses of tetanus and diphtheria are required to maintain immunity.

### **Recommendation by ACIP 2011:**

- Regardless of age, HCP should receive a single dose of Tdap (intramuscular) as soon as feasible if they have not previously received Tdap and regardless of the time since their most recent Td vaccination. After receipt of Tdap, HCP should receive Td for routine booster every 10 years.
- Vaccinating HCP with Tdap will protect them against pertussis and is expected to reduce transmission to patients, other HCP, household members, and persons in the community.
- Tdap is not licensed for multiple administrations; therefore, after receipt of Tdap, HCP should receive Td for future booster vaccination against tetanus and diphtheria.

## ***Varicella – Zoster*** **[6, 13, 22, 27, 74]**

### ***Organisms:***

The varicella zoster vaccine is an attenuated viral preparation in a lyophilized preparation.

### ***Administration:***

- One dose subcutaneous for persons ages 12 months to 12 years.
- Two 0.5 ml doses subcutaneous 4–8 weeks apart for those ages 13 and up.
- It is intended for non-immune children and health professionals without a reliable history of chickenpox or serologic laboratory evidence of immunity against varicella.
- Both children and adults should receive two injections of the vaccine given at least 28 days apart.
- A minority of vaccine recipients may develop a mild case of chickenpox from the first vaccine dose.
- The vaccine is not recommended for pregnant women and immune-compromised individuals.

### ***Protection and Safety:***

- The vaccine provides 70- 90% protection against varicella infection and 95% protection against severe disease for 5-10 years after vaccination. Serious complications caused by varicella are also reduced.
- Vaccines may potentially be capable of transmitting vaccine virus to close contacts. Vaccinated health care workers should therefore avoid close contact with susceptible high-risk individuals (e.g. newborns, pregnant women and immunocompromised persons).
- The varicella vaccine has an excellent safety profile.
- The most common adverse events among adolescents and adults were injection-site complaints. Varicella-like rash at the

injection site occurred in 1- 3% of vaccine recipients. A non-localized rash occurred in 0.9%-5.5% of vaccine recipients.

**Recommendation by ACIP 2011:**

- Health-care institutions should ensure that all HCP have evidence of immunity to varicella.
- Evidence of immunity for HCP includes any of the following:
  - written documentation of vaccination with 2 doses of varicella vaccine,
  - laboratory evidence of immunity or laboratory confirmation of disease,
  - diagnosis or verification of a history of varicella disease by a health-care provider, or
  - diagnosis or verification of a history of HZ by a health-care provider.
- This information should be documented in the medical record of HCP.
- Health care personnel without evidence of immunity to varicella should receive 2 doses of varicella vaccine administered 4–8 weeks apart (subcutaneous). If >8 weeks elapse after the first dose, the second dose may be administered without re-starting the schedule.
- Varicella-zoster immunoglobulin (125U/10 kg IM) should be given to persons without evidence of immunity who have contraindications for varicella vaccination, who are at risk for severe disease and complications, and who have direct, non-transient exposure to an infectious hospital staff worker or patient.
- Health care personnel who develop a vaccine-related rash after vaccination should avoid contact with persons without evidence of immunity to varicella who are at risk for severe disease and complications until all lesions resolve (i.e., are crusted over) or, if they develop lesions that do not crust (macules and papules only), until no new lesions appear within a

24-hour period.

- Serologic screening before vaccination of HCP without evidence of immunity is likely to be cost effective.
- A vaccine to prevent HZ is available and recommended for all persons aged  $\geq 60$  years without contraindications to vaccination.
- The HZ vaccine is not indicated for HCP for the prevention of nosocomial transmission, but HCP aged  $\geq 60$  years may receive the vaccine on the basis of the general recommendation for HZ vaccination, to reduce their individual risk for HZ.

### **Vaccinations Which Might be Indicated in Certain Circumstances [27]**

Health-care institutions should consider including in their vaccination programs other vaccines to prevent some diseases (such as meningococcal disease and polio) for HCP who have certain health conditions or who work in laboratories where the risk for work-related exposure exists.

#### ***Poliomyelitis Vaccine*** **[6-7, 22, 27, 66, 74]**

##### ***Organism:***

Live poliovirus types 1, 2 and 3 – Sabin vaccine or killed (inactivated) poliovirus – Salk vaccine.

##### ***Administration:***

- There are two types of vaccine that can prevent polio: inactivated polio vaccine (IPV) and oral polio vaccine (OPV).
- Inactivated poliovirus vaccine (IPV): 2 doses should be administered at intervals of 4–8 weeks; a third dose should be administered 6–12 months after the second dose. IPV is given in the leg or arm, depending on age.
- Inactivated poliovirus vaccine (IPV) was indicated only in people older than 18 years of age because of the slightly increased risk of vaccine-associated paralysis in adults after administra-

tion of live poliovirus (OPV).

- Now, there is a complete transition from use of oral poliovirus vaccine (OPV) to inactivated poliovirus vaccine (IPV) for all ages in USA and vaccine-associated paralytic poliomyelitis (VAPP) attributable to OPV is also avoidable.

### ***Protection and Safety:***

- Both vaccines are highly effective in polio prevention, 98% to 100% seroconversion occurs after two doses of vaccination.
- Booster doses are recommended for fully immunized health care providers only if there has been direct contact with oral secretions or feces of a person with poliomyelitis.
- Adults are slightly at increased risk for vaccine-associated paralysis (oral polio). The risk is one case for 1.2 million doses.

### **Recommendation by ACIP 2011:**

- Most adults do not need polio vaccine because they were already vaccinated as children.
- The childhood recommendation for poliovirus vaccine consists of 4 doses at ages 2, 4, and 6–18 months and 4–6 years.
- Occasional cases of poliomyelitis still occur; therefore, health care providers need to be vaccinated against this virus:
  1. Vaccination is recommended for HCP who are at greater risk for exposure to polioviruses than the general population, including laboratory workers who handle specimens that might contain polioviruses and HCP who have close contact with patients who might be excreting polioviruses, including HCP who travel to work in areas where polioviruses are circulating.
  2. Adults at higher risk who have never been vaccinated against polio should get 3 doses of IPV: the first dose at any time, the second dose 1 to 2 months later, and the third dose 6 to 12 months after the second.
  3. Adults at higher risk who have had 1 or 2 doses of

polio vaccine in the past should get the remaining 1 or 2 doses, regardless of how long it has been since the earlier dose(s).

4. Adults who are at increased risk of exposure to poliovirus and who have previously completed a routine series of polio vaccine (IPV or OPV) can receive one lifetime booster dose of IPV.

### ***Meningococcal Vaccine*** **[13, 22, 27, 69]**

#### ***Organism:***

Various preparations are available containing either: monovalent vaccine (containing group A immunogens), bivalent vaccine (containing group A & C immunogens), trivalent vaccine (containing group A, C & Y immunogens), or quadrivalent meningococcal conjugate vaccine-tetravalent vaccine (MCV4) (containing group A, C, Y & W135 immunogens). In 2010 a new meningococcal conjugate vaccine was licensed, pre-qualified by WHO. Conjugate vaccines generally result in higher levels of protection, longer duration of protection, protection of children less than 2 years of age, and may interrupt nasopharyngeal carriage and transmission.

#### ***Administration:***

- Use of MCV4 is preferred for persons younger than age 56 years (IM).
- If MCV4 is unavailable, the MPSV (quadrivalent meningococcal polysaccharide vaccine) is an acceptable alternative for HCP younger than age 56 years.
- Use of MPSV is recommended for HCP older than age 55(SC).

#### ***Protection and Safety:***

The vaccine is generally safe and effective for a 3-year duration in adults.

#### **Recommendation by ACIP 2011:**

- MCV4 is not recommended routinely for all HCP.

- However, HCP may become infected after direct contact with respiratory secretions of infected persons and in a laboratory setting (HCP can decrease the risk for infection by taking antimicrobial chemoprophylaxis if exposed directly to respiratory secretions):
  1. A 2-dose vaccine series is recommended for HCP with known asplenia or persistent complement component deficiencies, because these conditions increase the risk for meningococcal disease.
  2. Health care personnel traveling to countries in which meningococcal disease is hyperendemic or epidemic also are at increased risk for infection and should receive vaccine. They should receive a single dose of MCV4 before travel if they have never received it or if they received it more than 5 years previously.
  3. Clinical microbiologists and research microbiologists who might be exposed routinely to isolates of *N. meningitidis* should receive a single dose of MCV4 and receive a booster dose every 5 years if they remain at increased risk.
  4. Health-care personnel aged more than 55 years who have any of the above risk factors for meningococcal disease should be vaccinated with MPSV4.
  5. Health care personnel who receive the 2 doses MCV4 vaccine series and/or remain in a group at increased risk should receive a booster dose every 5 years.
  6. Health care personnel not otherwise indicated for vaccination may be recommended to be vaccinated with meningococcal vaccine in the setting of a community or institutional outbreak of meningococcal disease caused by a serogroup contained in the vaccine.

## ***Hepatitis A Vaccine*** **[22, 27]**

### ***Organism:***

The currently licensed hepatitis A vaccine is an inactivated vaccine and cannot cause hepatitis A.

### ***Administration:***

- Hepatitis A immunization requires a single dose in adults with a later booster dose 6 to 12 months to achieve maximum titers.
- Health care personnel have not been demonstrated to be at increased risk for hepatitis A virus infection because of occupational exposure, including persons exposed to sewage.
- Hepatitis A vaccine is recommended for person with chronic liver disease, and certain other groups at increased risk for exposure to hepatitis A (day care workers, HCP having contact with active cases, laboratory workers who handle live hepatitis A virus, food handlers, staff of institutions for mentally handicapped, chronic carriers of hepatitis B, persons with other chronic liver diseases, and international travelers).
- The vaccine should be given during pregnancy only if clearly needed.
- There are no other contraindications other than hypersensitivity to any of the known components of the vaccine.

### ***Protection and Safety:***

- All studies to date indicate that this vaccine is highly immunogenic with excellent safety profiles.
- After a single dose 80% to 90% have protective levels of antibody after 15 days and more than 96% seroconvert after 30 days.
- When a booster dose is given 6 months later, essentially 100% of recipients seroconvert.
- Protective antibody titers develop within 15-30 days after vaccination and persists for 5-10 years, and preliminary data suggest protective antibody levels may persist for between 16-25



- years.
- Post-vaccination serologic testing is not typically performed or required.

### ***Pneumococcal Vaccine*** **[22, 27]**

#### ***Organism:***

A polyvalent vaccine containing 23 strains.

#### ***Administration:***

- The vaccine is given either intramuscularly or subcutaneously in a dose of 0.5 ml.
- It is recommended for healthy persons aged  $\geq 65$  years. It is also recommended for persons aged  $< 65$  years with certain underlying medical conditions, including anatomic or functional asplenia, compromised immunity (including HIV infection), chronic lung, heart or kidney diseases, and diabetes.

#### ***Protection and Safety:***

- Efficacy rate ranges between 50 -70%.
- The vaccine is generally safe.
- Soreness and erythema at local injection sites occurs in 50% of recipients, and lasts for no more than 48 hours.
- Anaphylaxis was reported among persons frequently receiving the vaccine more than indicated (a minimum of 6 years is recommended between repeated doses).

### ***BCG Vaccine (Bacillus Calmette-Guérin)*** **[6-7, 74]**

#### ***Organism:***

The vaccine contains live *M. bovis* attenuated by propagation in a bile-potato medium, and is active against *Mycobacterium tuberculosis*.

#### ***Administration:***

Single dose intradermally in the deltoid muscle.

**Table 7**

**Immunizing Agents Recommended for Health Care Personnel**

Generic name	Recommendation	Primary booster dose schedule	Indications	Contraindications	Special considerations
Hepatitis B recombinant vaccine	<p><b>REQUIRED</b></p> <p>According to the Ministry of Health Regulation immunization against hepatitis B should be completed during health professional training because the risk for infection is thought to be highest at this time</p> <p>If an DHCP declines the vaccination, the DHCP must sign a declination form</p>	<p>Two doses IM in the deltoid muscle 4 weeks apart; 3rd dose 5 months after 2nd; booster dose is not necessary</p>	<p><u>ACIP:</u> All Health care personnel at risk of exposure to blood and body fluids.</p> <p><u>MOH:</u> All persons at risk of contact with blood, blood products, or other body secretions.</p>	<p>History of anaphylactic reaction to common baker's yeast. Not contraindicated in pregnancy ( no apparent adverse effects to developing fetuses);</p>	<p>According to the Ministry of Health Regulation, serologic screening is necessary before immunization (to identify positive cases and instruct them about preventive measures). The CDC recommends that health care personnel who have ongoing contact with patients or blood should be tested 1-2 months after completing the vaccination series to determine serologic response</p> <p>Vaccine immunogenicity is related to several factors such as concomitant medical conditions. gender, age, body weight, and smoking status</p>
Influenza vaccine (inactivated whole or split virus)	<p><b>RECOMMENDED</b></p>	<p>Annual with current seasonal vaccine -single dose vaccination IM (either whole or split-virus) Give TIV intramuscularly or intradermally; or LAIV intranasally.</p>	<p><u>ACIP:</u> All HCP.</p> <p><u>MOH:</u> All health care workers caring for high-risk persons*.</p>	<p>History of anaphylactic hypersensitivity after egg ingestion</p> <p>Known hypersensitivity to egg proteins.</p> <p>Persons who developed (Guillain-Barré Syndrome) or other neurologic syndromes related to influenza immunization.</p> <p>No evidence of maternal or fetal risk when vaccine was given to pregnant women with underlying conditions that render them at high risk for serious influenza complications.</p>	<p>Side effects:</p> <p>Low-grade fever, soreness at the vaccination site (affecting 10%–64% of patients) that lasted &lt;2 days. Rarely Guillain-Barré syndrome (GBS) may occur especially among adults &lt;65 years</p> <p>Influenza vaccination is recommended for women who are or will be pregnant during influenza season because of increased risk for hospitalization and death.</p> <p>LAIV is recommended only for healthy, non-pregnant persons aged 2–49 years. Intradermal vaccine is indicated for persons aged 18–64 years. HCP who care for severely immunosuppressed persons who require a protective environment should receive TIV rather than LAIV.</p>

Measles live virus vaccine	RECOMMENDED	2 doses SC; ≥28 days apart	<u>ACIP</u> : All HCP who lack evidence of immunity <u>MOH</u> : All health care workers at risk of contact with patients with measles, or are likely to have direct contact with pregnant women.	Pregnancy; immunocompromised** state; history of anaphylactic reactions after gelatin ingestion or receipt of neomycin; hypersensitivity to egg; or recent receipt of immuneoglobulin	MMR is the vaccine of choice if recipients are also likely to be susceptible to rubella and/or mumps; give 2 doses of MMR, 4 weeks apart. HCP vaccinated during 1963–1967 with a killed measles vaccine alone, killed vaccine followed by live vaccine, or a vaccine of unknown type should be revaccinated with 2 doses of live measles virus vaccine. Side effects: Fever can occur in up to 15% of recipients. Transient rashes occur in up to 5% of recipients.
Mumps live virus vaccine	RECOMMENDED	2 doses SC; ≥28 days apart	<u>ACIP</u> : All HCP who lack evidence of immunity <u>MOH</u> : All health care workers at risk of contact with patients with mumps or are likely to have direct contact with pregnant women.	Pregnancy; immunocompromised persons,** anaphylaxis to gelatin or gelatin-containing products; anaphylaxis to neomycin; hypersensitivity to egg	MMR is the vaccine of choice if recipients are also likely to be susceptible to measles and rubella give 2 doses of MMR, 4 weeks apart. HCP vaccinated before 1979 with either killed mumps vaccine or mumps vaccine of unknown type should consider revaccination with 2 doses of MMR vaccine.  Side effects: Fever can occur in up to 15% of recipients. Transient rashes occur in up to 5% of recipients. Parotitis and encephalitis have rarely been reported.

<p>Rubella live virus vaccine</p>	<p>RECOMMENDED</p>	<p>1 dose SC; (However, due to the 2-dose requirements for measles and mumps vaccines, the use of MMR vaccine will result in most HCP receiving 2 doses of rubella-containing vaccine.)</p>	<p><u>ACIP</u>: All HCP who lack evidence of immunity <u>MOH</u>: All health care workers at risk of contact with patients with rubella or are likely to have direct contact with pregnant women.</p>	<p>Pregnancy; immunocompromised** state; history of anaphylactic reaction after receipt of neomycin; hypersensitivity to egg;</p>	<p>Women who are pregnant when vaccinated or who become pregnant within 3 mo of vaccination should be counseled on the theoretic risks to the fetus, the risk of rubella vaccine-associated malformations in these women is negligible; MMR is the vaccine of choice if recipients are also likely to be susceptible to measles or mumps; give 2 doses of MMR, 4 weeks apart.</p> <p>Side effects: Fever can occur in up to 15% of recipients. Transient rashes occur in up to 5% of recipients. Transient arthralgias or arthritis may occur among 40% of susceptible adult women. Peripheral neuritis of short duration has been reported.</p>
<p>Varicella vaccine (varicella zoster virus live-virus vaccine)</p>	<p>RECOMMENDED</p>	<p>Two 0.5 ml doses SC 4–8 weeks apart if aged ≥13 years.</p>	<p><u>ACIP</u>: All HCP who do not have evidence of immunity. <u>MOH</u>: Susceptible persons working in close contact with high risk groups*; and day care workers and staff of institutional settings.</p>	<p>Pregnancy, immunocompromised** state, history of anaphylactic reaction after receipt of neomycin or gelatin; Persons with blood dyscrasias; malignant neoplasms affecting bone marrow or lymphatics; during febrile respiratory illness; persons with active untreated tuberculosis. Vaccination should be avoided for at least five months following blood or plasma transfusions. Salicylate use should be avoided for 6 weeks after vaccination.</p>	<p>Because 71%-93% of persons without a history of varicella are immune, serologic testing before vaccination may be cost effective.</p>

<p>Tetanus and diphtheria (toxoids) and acellular pertussis (Tdap)</p>	<p>RECOMMENDED</p>	<p>One dose IM as soon as feasible if Tdap not already received and regardless of interval from last Td. After receipt of Tdap, routine booster of Td every 10 years.</p>	<p><u>ACIP:</u> All HCP, regardless of age. <u>MOH:</u> Health care workers during outbreaks of diphtheria especially those working in contact with persons traveling from newly independent Russian states</p>	<p>History of serious allergic reaction (i.e., anaphylaxis) to any component of Tdap. Because of the importance of tetanus vaccination, persons with history of anaphylaxis to components in Tdap or Td should be referred to an allergist to determine whether they have a specific allergy to tetanus toxoid and can safely receive tetanus toxoid (TT) vaccine. Persons with history of encephalopathy (e.g., coma or prolonged seizures) not attributable to an identifiable cause within 7 days of administration of a vaccine with pertussis components should receive Td instead of Tdap.</p>	<p>Tetanus prophylaxis included in wound management if Tdap not yet received.</p>
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<p>Quadri-valent meningococcal conjugate vaccine-tetavalent (MCV4) for HCP ages 19–54 years, Quadri-valent meningococcal polysaccharide vaccine (MPSV4) for HCP age &gt;55 years</p>	<p>RECOMMENDED in special circumstances</p>	<p>One dose either IM or SC in 0.5 ml dose 10days before expected exposure; booster dose in 5 years if person remains at increased risk</p>	<p><u>ACIP</u>: Clinical and research microbiologists who might routinely be exposed to isolates of Neisseria meningitides; HCP with known asplenia or persistent complement component deficiencies; HCP traveling to countries in which meningococcal disease is hyperendemic or epidemic, and clinical microbiologists and research microbiologists who might be exposed routinely to isolates of N. meningitides. HCP in a community or institutional outbreak of meningococcal disease. <u>MOH</u>: All health care workers during epidemics outbreaks or those working in endemic regions; all health care workers in high-risk conditions (during Al-Hajj season).</p>	<p>Acute infectious diseases; Current evolving diseases (acute or chronic). Vaccine safety in pregnant women has not been evaluated; vaccine should not be given during pregnancy unless risk of infection is high.</p>	
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<p>Inactivated poliovirus vaccine (IPV)</p>	<p>RECOMMENDED in special circumstances</p>	<p>For unvaccinated adults, 2 doses should be administered at intervals of 4–8 weeks; a third dose should be administered 6–12 months after the second dose.</p>	<p><u>ACIP</u>: Vaccination is recommended for adults at increased risk for exposure to polioviruses including laboratory workers who handle specimens that might contain polioviruses and HCP who have close contact with patients who might be excreting polioviruses, including HCP who travel to work in areas where polioviruses are circulating. Adults who have previously received a complete course of poliovirus vaccine may receive one lifetime booster if they remain at increased risk for exposure. <u>MOH</u>: Health care workers at increased risk of exposure to poliovirus.</p>	<p>Immunocompromised** persons; hypersensitivity or anaphylactic reactions to IPV or antibiotics contained in IPV. IPV contains trace amounts of streptomycin, polymyxin B, and neomycin.</p>	
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Hepatitis A	RECOMMENDED in special circumstances	Hepatitis A immunization requires a single dose in adults with a later booster dose 6 to 12 months to achieve maximum titers.	<p><u>ACIP</u>:HCP have not been demonstrated to be at increased risk for hepatitis A virus infection. Hepatitis A vaccine is recommended for person with chronic liver disease, international travelers, and certain other groups at increased risk for exposure to hepatitis A.</p> <p><u>MOH</u>: Hepatitis A vaccine is indicated for pre-exposure prophylaxis against hepatitis A infection for day care workers, HCP having contact with active cases and laboratory workers who handle live hepatitis A virus, food handlers, staff of institutions for mentally handicapped, chronic carriers of hepatitis B, persons with other chronic liver diseases</p>	The vaccine should be given during pregnancy only if clearly needed There are no other contraindications other than hypersensitivity to any of the known components of the vaccine	Post-vaccination serologic testing not typically performed or required.
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IM, Intramuscularly; SC, subcutaneously.MMR, Measles Mumps Rubella

\* high risk groups: such as neonates, infants, elderly, patients with chronic underlying illness, or immunocompromised patients.

\*\*Persons are immunocompromised because of immune deficiencies, HIV infection, leukemia, lymphoma, generalized malignancy, or immunosuppressive therapy with corticosteroids, alkylating drugs, antimetabolites, or radiation.

Source: *KKUH Infection Control Department [13], Saudi Arabian MOH [22], CWRU School Of Dental Medicine [25], CDC [27], Dalhousie University [29]*



## Contraindications to Immunization

[6-7, 74]

- Adverse reactions to vaccines almost always are caused by hypersensitivity to one or more vaccine components such as residual animal proteins, antibiotics, preservatives, or stabilizers.
- The most common allergenic component is egg protein found in vaccines prepared in embryonated chicken eggs or chicken embryonal cultures (i.e., measles, mumps, and influenza).
- People who can eat eggs or egg-containing products can receive these vaccines, but vaccination is contraindicated for people with a history of anaphylactic reaction to eggs or egg proteins.
- On rare occasions, patients will have an anaphylactic reaction to neomycin found in trace amounts in the measles, mumps, and rubella vaccine and streptomycin found in the oral polio vaccine.
- In general, immunizations with live virus vaccines should be avoided in immunocompromised patients and during pregnancy.

## **OCCUPATIONAL EXPOSURE, EXPOSURE INCIDENT AND DOCUMENTATION**

### **[10, 25, 27]**

Avoiding occupational exposures to blood is the primary way to prevent transmission of hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV), to DHCP in health-care settings. An exposure incident refers to percutaneous injury (e.g., a needlestick or cut with a sharp object such as a scalpel blade, bur, or scaler) or contact of specific mucous membranes (eye, nose, mouth) or non-intact skin (e.g., exposed skin that is chapped, abraded, or shows signs of dermatitis) with blood or OPIM that results from the performance of one's duties or tasks.

### **Dental Health-Care Personnel (DHCP)**

#### **[10, 13, 16, 28]**

Persons who have direct contact with patients, including dentists, hygienists, dental assistants, clinical faculty, technicians, residents and dental students, are more likely to be involved in disease transmission. These persons may become infected through exposure to infected patients or exposure outside the facility. In either case they may transmit the infection to patients, other DHCP, members of their household, or other community contacts.

All DHCP are responsible for monitoring their own health status. Those who have acute or chronic medical conditions that render them susceptible to opportunistic infection should discuss with their personal physicians whether the condition might affect their ability to safely perform their duties. The health status of DHCP can be monitored by maintaining records of work-related medical evaluations, screening tests, immunizations, exposures, and postexposure management. It is the responsibility of all DHCP at risk of exposure to blood or body fluids to secure receipt of a full course of the Hepatitis B vaccine and to observe standard precautions.

Those DHCP who might reasonably be considered at risk of occupational exposure to blood or other potentially infectious fluids should be taught strategies to prevent exposures and the principles of post

exposure management, including options for post exposure prophylaxis, as part of their job orientation and ongoing training. Under certain circumstances, dental health-care facility managers might need to exclude DHCP from work or patient contact to prevent further transmission of infection.

### ***Tasks and Procedures which may Result in Occupational Exposure in the Dental Facility***

Tasks and procedures which may result in occupational exposure in the dental facility include the following:

1. Patient treatment procedures.
2. Radiographic procedures.
3. Cleaning, disinfection and sterilization of instruments.
4. Environmental surface and equipment disinfection.
5. Dental laboratory procedures.
6. Handling contaminated laundry.
7. Handling infectious waste.
8. Repairing dental equipment.
9. Handling infectious tissues and body fluids in different laboratories.

### ***Dental Health Care Personnel at Risk of Occupational Exposures***

Dental health care personnel at risk of occupational exposures include the following:

1. Dental health care providers (including: Dentists; hygienists; students; residents; and trainees).
2. Dental assistants.
3. Radiology department technicians.
4. Sterilization center technicians.
5. Dental laboratory technicians.

6. Microbiology laboratory technicians.
7. Histopathology laboratory technicians.
8. Research laboratory technicians.
9. Maintenance technicians.
10. Janitorial personnel.

### **Employee Health Services** **[13, 22]**

The following infection control activities of a personnel health service must be observed before and during the placement of all DHCP:

1. Pre-employment Evaluation: All potential staff members must have a medical examination and certain screening procedures in their country of recruitment and on arrival. This pre-employment medical check-up will ensure that persons are not placed in jobs that would pose undue risk of infection to them, other personnel, patients, or visitors.
2. For infection control purposes, the following screening laboratory tests must be performed:
  - a. Serologic tests for syphilis, hepatitis B, C, and HIV infections.
  - b. Tuberculin (TB) skin test and chest X-ray.
  - c. Urinalysis including pregnancy test.
  - d. Stool screening for parasites and enteropathogenic bacteria.
  - e. Varicella antibody screening.
3. According to the Saudi Arabian Ministry of Health Regulations, applicants who have an established infection, such as tuberculosis or syphilis, or are carriers of HBV or HIV will be considered as non fit to work.
4. Before signing the employment contract, all potential DHCP irrespective of their recruitment origin must have an initial

evaluation by the Employee Health Department which includes the following:

- a. Complete history. History taking should enquire regarding any communicable disease the person may have had, and any chronic infection or skin disease.
- b. Psychological requirements. According to the Ministry of Health Regulation, health employees should be free from any psychological or mental troubles that can affect their full work capacity.
- c. General physical examination.
- d. Screening laboratory tests. Lab investigations should include complete blood count; biochemistry laboratory tests, serologic tests for syphilis, hepatitis B, C, and HIV; tuberculin skin test; chest X-ray, taken within the previous 3 months; urinalysis; pregnancy test; and stool screen for parasites and enteric pathogens.
- e. Varicella screening. Enquiries should be made regarding history of varicella infection. Those with doubtful or no history of infection should be screened. If negative for anti-varicella IgG, they should receive the varicella vaccine.
- f. Hepatitis B screening. Personnel with negative anti HBs should receive hepatitis B vaccine series.
- g. Medical requirements: According to the Ministry of Health Regulations, health care workers should be free from the following health problems if they affect their full work capacity or render them at high risk of nosocomial infections:
  - i. Any incapacitating congenital anomalies.
  - ii. Cardiac diseases.
  - iii. Uncontrolled Hypertension.
  - iv. Uncontrolled Diabetes, Chronic chest diseases.

- v. Chronic liver diseases.
- vi. Tumors.
- vii. History of major surgical operations which may affect physical and/or mental capacity.
- viii. Renal disorders.
- ix. Diseases needing major surgical operations.
- x. Hearing, visual and/or speech disorders which can affect work performance.
- xi. Locomotor deficits, which can affect his work performance.
- xii. Lab tests should prove freedom from:
  - a. Hepatitis B & C
  - b. Sexually transmitted diseases including AIDS.
  - c. Carriage of salmonella organisms causing typhoid fever.
  - d. Carriage of vibrio cholera
  - e. Parasitic infections which include: Malaria, Bilharziasis, Filriasis, Intestinal parasites.

## **Management of Needlestick Injuries/Blood And Body Fluid Exposure**

**[13, 28, 77]**

### ***I. First Aid:***

#### *Percutaneous Injuries (Needlestick/ Sharp Injury)*

1. Allow the site to bleed.
2. Wash generously with soap and water.
3. Cleanse with alcohol wipes. However, there is no evidence that using antiseptics or expressing fluid by squeezing the

wound reduces the risk of transmission. Extraordinary measures, such as soaking injured tissues in bleach, excessive scrubbing, or doing anything else that challenges the integrity of skin, should be avoided.

4. Cover with appropriate bandages.

#### *Mucocutaneous Exposures (Body Fluid Exposure)*

1. Remove contaminated clothing (if necessary).
2. Irrigate affected area with copious amounts of water (10 minutes).

### ***II. Reporting of Exposures:***

All percutaneous injuries and mucocutaneous exposures must be reported. The incident report should include:

- a. Time and date of incident.
- b. Location.
- c. Source patient if known: Risk factors for the source patient include:
  - High-risk sexual behavior
  - Intravenous drug use
  - Tattoo/body piercing
  - Transfusion of blood and blood product before 1990
  - Origin in developing country
  - Dialysis
- d. Description of incident (including first aid measures)

Exposed personnel should attend the employee health clinic (EHC) during normal working hours or the emergency room (ER) after hours. It is the responsibility of the Employee Health physician to take the history from the DHCP and document the details. History to include:

- a. Mechanism of injury.

- b. Site of injury.
- c. Amount and type of blood/body fluid, and an indication of the severity of the exposure e.g. degree of penetration of the needle, inoculation.
- d. Immediate action taken (first aid).
- e. Source patient serology status.

It is the responsibility of the EHC/ER physician to request the following baseline lab investigations (as required) on the DHCP after obtaining consent and/or counseling:

- a. HBsAg
- b. Anti-HBs
- c. Anti-HCV
- d. Anti-HIV.

**NOTE:**

1. The incident report should be taken for physician documentation.
2. The injury should be reported within 24 hours of the incident for risk assessment and prophylaxis where indicated. Since documentation of any exposure management is essential to support future compensation claims, notification must be made within 72 hours.
3. All DHCP should report to the employee health clinic despite attendance at emergency room, as the EHC physician is responsible for determining the need and type of follow-up.

***III. Evaluating The Exposure:***

Each occupational exposure should be evaluated individually. This evaluation should be based on:

- a. the type and amount of body substance involved;
- b. the type of exposure (e.g. percutaneous injury, expo-



- sure of mucous membranes or nonintact skin, bites resulting in blood exposure to either person involved);
- c. the infection status of the source; and
  - d. the susceptibility of the exposed person.

All of these factors should be considered in assessing the risk of infection and the need for further follow-up.

#### ***IV. Prophylactic Treatment:***

- When prophylactic treatment with drugs, vaccines, or immune globulins is necessary, it should be offered and personnel should be informed of risk of infection, alternative means of prophylaxis, degree of protection provided by the therapy, and potential side-effects.
- Hepatitis B (HBV) prophylaxis, when indicated, should be initiated within 48 hours of the exposure incident and no later than 7 days.
- No post exposure prophylaxis or vaccination is available for Hepatitis C (HCV).
- HIV prophylaxis when indicated should be initiated as soon as possible following exposure and no later than 24 hours.

#### ***V. Documentation:***

The incidence should be properly documented in the confidential medical records of the DHCP.

### **Documentation**

**[16, 25]**

Certain records, including medical records and training records, should be kept for documentation and as part of infection control and exposure control programs.

### ***Medical Records***

An accurate record should be established and maintained for each DHCP with occupational exposure. This record shall include the fol-

lowing:

1. Demographic data including basic information such as the DHCP's name, identification card (ID) number, age, gender, nationality, marital status, address, and phone number.
2. General health history updated regularly including health problems that may affect DHCP's full work capacity or render them at high risk of nosocomial infections.
3. The results of all pre-employment evaluation and screening laboratory tests (see section on Employee Health Services).
4. A list of all vaccinations received (and to be received) by the DHCP, documented by a physician.
5. A copy of the DHCP's Hepatitis B vaccinations and any medical records relative to the health care worker's ability to receive vaccination as required by the section on Hepatitis B vaccination. If the staff member declines the vaccination, documentation of refusal is kept in the file.
6. A copy of the following information (provided previously to DHCP) signed by DHCP:
  - a. A description of the DHCP's job description.
  - b. A document signed by the DHCP stating that they have received a copy of the applied policies and procedures related to his/her duties.
7. In case of exposure incident, the following should be included in the medical record:
  - a. A copy of all results of examinations and medical testing as required by the section on Management of Needlestick Injuries and Management of Exposures (of different infectious diseases).
  - b. A description of the DHCP's duties as they relate to the exposure incident.
  - c. A copy of Incident Report Form.

- d. Results of the source individual's blood testing, if available.
- e. Details regarding counseling, postexposure management, and follow-up including vaccination status.

### ***Confidentiality***

The administration of the dental facility shall ensure that the required health care worker medical records are:

1. Kept confidential.
2. Not disclosed or reported without the health care worker's express written consent to any person within or outside the workplace except as required by law.
3. Maintained for at least the duration of employment plus 30 years.

### ***Training Records***

Training records of the DHCP shall include the following information:

1. The dates of the training sessions;
2. The contents or a summary of the training sessions;
3. The names and qualifications of persons conducting the training;
4. The names and job titles of all persons attending the training sessions.

Training records shall be maintained for three years from the date on which the training occurred.

## **WORK RESTRICTION AND MANAGEMENT OF JOB-RELATED ILLNESSES**

**[3, 10, 13, 37, 75, 78-80]**

A major function of the personnel health service is to arrange for prompt diagnosis and management of job-related illnesses and provide prophylaxis for certain preventable diseases to which personnel may be exposed. It is the responsibility of the health care organization to implement measures to prevent transmission of infection, which sometimes warrants exclusion of personnel from work or patient contact. Decisions concerning work restrictions are based on the mode of transmission and the period of infectivity of the disease (Table 8).

Health care organization should develop and have readily available to all DHCP comprehensive written policies regarding work restriction and exclusion that include a statement of authority defining who can implement such policies. The policies for work restriction and exclusion should encourage DHCP to seek appropriate preventive and curative care and report their illnesses, medical conditions, or treatments that can render them more susceptible to opportunistic infection or exposures; and should not penalize DHCP with loss of wages, benefits, or job status.

The term exclude from duty in this document should be interpreted as exclusion from the health care facility and from health care activities outside the facility. Personnel who are excluded should avoid contact with susceptible persons both in the facility and in the community.

According to USA Advisory Committee on Immunization Practices (ACIP) 2011, HCP positive for HBsAg (e.g., acute or chronic hepatitis B infection) should not perform exposure-prone invasive procedures until they have sought counsel from an expert review panel, which should review and recommend the procedures the worker can perform, taking into account the specific procedure as well as the skill and technique of the worker. Exposure prone procedures (EPP) have been characterized by the CDC as those procedures which “include digital palpation of a needle tip in a body cavity or the simultaneous presence of the HCP’s fingers and a needle or other sharp instrument or object in a

poorly visualized or highly confined anatomic site.” The UK Dept. of Health, defines EPPs as procedures in which “there is a risk that injury to the worker may result in exposure of the patient’s open tissues to the blood of the worker. These procedures include those where the worker’s gloved hands may be in contact with sharp instruments, needle tips or sharp tissues (spicules of bone or teeth) inside a patient’s open body cavity, wound or confined anatomical space where the hands or fingertips may not be completely visible at all times.” It further states that “The majority of procedures in dentistry are exposure prone”. Furthermore, the Saudi Arabian Ministry of Health classifies dental procedures as risk procedures.

### **Work Restriction According to the Ministry of Health Regulation (Regarding Hepatitis B and C) [37]**

- All DHCP should be screened for markers of HBV (HBsAg) and HCV (Anti-HCV).
- PCR test for HBV and HCV should also be done for all DHCP performing exposure prone procedures
- DHCP (performing exposure prone procedures) with positive HBsAg and positive PCR and the viral load is more than 100,000 copy/ml should be restricted from performing exposure prone invasive procedures and they should work in an area where transmission of the infection to patients could be avoided.
- DHCP (performing exposure prone procedures) with positive HBsAg and negative PCR or the viral load is less than 100,000 copy/ml on two tests one month apart should not be restricted from work, provided that the test is repeated yearly. Once the viral load becomes more than 100,000 copy/ml, work restriction applies.
- DHCP (performing exposure prone procedures) with positive Anti-HCV and positive PCR should be restricted from performing exposure prone invasive procedures and they should

work in an area where transmission of the infection to patients could be avoided.

- DHCP (performing exposure prone procedures) with positive Anti-HCV and negative PCR should not be restricted from work.
- All health care workers with negative PCR for HCV tested twice, at least one month apart, are considered free of the disease.
- All health care workers receiving treatment for HCV and proven to be cured from the disease with negative PCR for 6 months after receiving the treatment are considered free of the disease.

**Table 8***Important Recommendations and Suggested Work Restrictions for Personnel with Selected Infectious Diseases*

Disease/problem	Work Restriction	Duration
Conjunctivitis (infectious)	Restrict from patient contact and contact with the patient's environment	Until discharge ceases
Diphtheria	Exclude from duty	Until antimicrobial therapy completed and 2 cultures obtained >24 hours apart are negative
Hepatitis A	Restrict from patient contact, contact with patients' environment, and food-handling	Until 7 days after onset of jaundice.
Hepatitis B (According to MOH Regulation dated 18.02.1427)	<p>a. No restriction, but viral load must be checked with PCR yearly. If becomes &gt; 100,000 copy/ml, the following restriction applies.</p> <p>b. Restriction from performing exposure prone invasive procedures.</p>	<p>Council may be sought from an expert review panel, which should review and recommend the procedures the worker can perform, taking into account the specific procedure.</p>
Hepatitis C diagnosed by PCR (According to MOH Regulation dated 18.02.1427)	Restrict from performing exposure prone invasive procedures.	
Human immune deficiency Virus (HIV)	Restrict from performing exposure prone invasive procedures.	

Herpes simplex Hands (herpetic whitlow)	Restrict from patient contact and contact with the patient's environment	Until lesions heal.
Herpes simplex Orofacial	Evaluate the need to restrict from care of high-risk patients	
Measles Active	Exclude from duty	Until 4 days after the rash appears
Measles Post exposure (susceptible personnel)	Exclude from duty	From the 5th day after exposure through 21st day after exposure and/or 4 days after rash appears.
Mumps Active	Exclude from duty	Until 5 days after onset of parotitis
Mumps Post exposure (susceptible personnel)	Exclude from duty	From 12th day after exposure through 25th day after exposure and/or until 5 days after onset of parotitis.
Rubella Active	Exclude from duty	Until 7 days after rash appears
Rubella Post-exposure (susceptible personnel)	Exclude from duty	From 7th day after through 21st day after exposure and/or 7 days after rash appears
Meningococcal infection	Exclude from duty	Until 24 hours after the start of effective therapy.
Pertussis Active	Exclude from duty	From the beginning of the catarrhal stage through 3rd week after onset of paroxysms or until 5days after start of effective antimicrobial therapy.
Pertussis Post exposure (asymptomatic personnel)	No restriction, prophylaxis recommended	
Pertussis Post exposure (symptomatic personnel)	Exclude from duty	Until 5days after start of effective antimicrobial therapy.



Staphylococcus aureus infection Active, draining skin lesions	Restrict from contact with patients and patient's environment or food handling	Until lesions have resolved.
Staphylococcus aureus infection Carrier state	No restriction, unless personnel are epidemiologically linked to transmission of the organism or outbreak of MRSA infection. These personnel should be cultured and, if positive, removed from patient contact and undergo decolonization therapy.	until documented to be negative from MRSA.
Streptococcal infection, group A	Restrict from patient care, contact with patient's environment or food handling	Until 24 hours after adequate treatment started.
Tuberculosis Active disease	Exclude from duty	Until proved noninfectious
Tuberculosis PPD converter	No restriction	
Varicella Active	Exclude from duty	Until all lesions dry and crust. If only lesions that do not crust (i.e., macules and papules), until no new lesions appear within a 24-hour period
Varicella Post-exposure (susceptible personnel)	Exclude from duty unless receipt of the second dose within 3-5 days after exposure	From the 8th day after 1st exposure through 21st day (28th day if VZIG given) after the last exposure; if varicella occurs, until all lesions dry and crust or, if only lesions that do not crust (i.e., macules and papules), until no new lesions appear within a 24-hour period
Zoster Localized, in healthy person	Cover lesions; restrict from care of high-risk patients	Until all lesions dry and crust

Zoster Generalized or localized in immunosuppressed person until generalized infection is ruled out	Exclude from duty	Until all lesions dry and crust
Zoster Post-exposure (suscep- tible personnel) Generalized zoster or lo- calized zoster with uncon- tained/uncovered lesions	Exclude from duty unless receipt of the second dose of varicella vaccine within 3–5 days after exposure	From the 8th day after 1st exposure through 21st day (28th day if VZIG given) after the last exposure; if varicella occurs, until all lesions dry and crust or, if only lesions that do not crust (i.e., macules and papules), until no new le- sions appear within a 24- hour period
Zoster Post-exposure (suscep- tible personnel) Localized zoster with con- tained/covered lesions	For HCP with at least 1dose of varicella vaccine, no work restrictions. For HCP with no doses of varicella vaccine, restrict from patient contact	From the 8th day after 1st exposure through 21st day (28th day if VZIG given) after the last exposure; if varicella occurs, until all lesions dry and crust or, if only lesions that do not crust (i.e., macules and papules), until no new le- sions appear within a 24- hour period
Viral respiratory infections, acute febrile	Consider excluding from the care of high risk pa- tients or contact with their environment during com- munity outbreak of Re- spiratory Syncytial Virus RSV and influenza	Until acute symptoms re- solve

Source: CDC [10], KKHU [13], CDC [27], Bolyard , et al. [75], MOH [37]

## NOTIFICATION OF INFECTIOUS DISEASES [13]

Notification of infectious diseases is one of the basic element of the surveillance system which is the corner stone in the control and prevention of infectious diseases. Notification is the process of informing the Health Authorities (Ministry of Health) about the occurrence of a disease that should be notified.

All patients diagnosed with one of the diseases that should be notified must be recorded by the Infection Control Officer who will forward that information to the Chairman of Infection Control Unit.

### ***Objectives of Notification:***

1. To identify the public health problems.
2. To take preventive and control measures against infectious diseases.
3. To allocate the necessary resources to solve major health problems.
4. To identify the epidemiological change for the disease.
5. To help eradication of some diseases.

### ***Examples of infectious diseases that should be notified:***

1. Tetanus
2. Polio cases
3. Hepatitis A
4. Hepatitis B
5. Hepatitis C
6. Unspecified Hepatitis
7. HIV
8. Syphilis
9. Diphtheria
10. Measles

11. Mumps
12. Rubella
13. Pertussis (whooping cough)
14. Meningitis
15. Varicella (chicken pox)

## HAND HYGIENE

Hand hygiene is an important component of any infection control program. Its primary purpose is the mechanical removal of transient microorganisms from the skin of HCP, preventing cross infection from contaminated hands [6]. Increased frequency of hand hygiene procedures is associated with decreased transmission of micro-organisms and a reduction in the incidence of health-care-associated infections [81].

### Selected Definitions [81-82]

- Alcohol-based hand rub: An alcohol-containing preparation designed for application to the hands for reducing the number of viable microorganisms on the hands. In the United States, such preparations usually contain 60%–95% ethanol or isopropanol.
- Antimicrobial soap: Soap (i.e., detergent) containing an antiseptic agent.
- Antiseptic agent: Antimicrobial substances that are applied to the skin to reduce the number of microbial flora. Examples include alcohols, chlorhexidine, chlorine, hexachlorophene, iodine, chloroxylenol (PCMX), quaternary ammonium compounds, and triclosan.
- Antiseptic handwash: Washing hands with water and soap or other detergents containing an antiseptic agent.
- Antiseptic hand rub: Applying an antiseptic hand-rub product to all surfaces of the hands to reduce the number of microorganisms present.
- Bacteriostatic: Inhibit bacterial growth (the suffix “-static” following the name of an organism or group of organisms indicates prevention of growth of such organisms).
- Bacteriocidal: Has the ability to kill bacteria (the suffix “-cidal” following the name of an organism or group of organisms indicates the ability to kill such organisms).
- Cumulative effect: A progressive decrease in the numbers of microorganisms recovered after repeated applications of a

- hygiene product.
- Decontaminate hands: To Reduce bacterial counts on hands by performing antiseptic hand rub or antiseptic handwash.
  - Detergent or soap: i.e., surfactants, are compounds that possess a cleaning action.
  - Hand antiseptics: Refers to either antiseptic handwash or antiseptic hand rub.
  - Hand hygiene: A general term that applies to either handwashing, antiseptic handwash, antiseptic hand rub, or surgical hand antiseptics.
  - Handwashing: Washing hands with plain (i.e., non-antimicrobial) soap and water.
  - Persistent or residual activity: The prolonged or extended antimicrobial activity that prevents or inhibits the proliferation or survival of microorganisms after application of the product.
  - Surgical hand antiseptics: Antiseptic handwash or antiseptic hand rub performed preoperatively by surgical personnel to eliminate transient and reduce resident hand flora using Antiseptic detergent preparations which have persistent antimicrobial activity.
  - Visibly soiled hands: Hands showing visible dirt or visibly contaminated with proteinaceous material, blood, or other body fluids.

### **Hand Hygiene Product Categories [81]**

The following is the Food and Drug Administration (FDA) (of the United States Government) hand hygiene product categories:

- *Patient preoperative skin preparation:*  
A fast-acting, broad spectrum, and persistent antiseptic-containing preparation that substantially reduces the number of microorganisms on intact skin.
- *Antiseptic handwash or HCP handwash:*  
An antiseptic-containing preparation designed for frequent use; it reduces the number of microorganisms on intact skin to an initial

baseline level after adequate washing, rinsing, and drying; it is broad-spectrum, fast-acting, and if possible, persistent.

- *Surgical hand scrub:*

An antiseptic-containing preparation that substantially reduces the number of microorganisms on intact skin; it is broad-spectrum, fast-acting, and persistent.

### **Transmission of Pathogens Through Hands [81, 83]**

Transmission of health-care-associated pathogens from one patient to another via the hands of HCP requires the following:

1. Organisms present on the patient's skin, or that have been shed on objects, must be transferred to the hands of HCP.
2. These organisms must be able to survive for at least several minutes on the hands of the HCP.
3. Health care personnel's handwashing or hand antisepsis is inadequate or omitted, or the antiseptic agent used is inappropriate.
4. The contaminated hands of the HCP must come in direct contact with another patient, or with an inanimate object that will come into direct contact with the patient.

Touching intact areas of moist skin of the patient transfer organisms to the hands more than dry surfaces. Wet hands have been described to significantly increase the risk of cross-transmission, indicating that hands should always be thoroughly dried.

Thus, to break the chain of transmission of potential pathogens via the hands of HCP, hand hygiene must be performed when indicated (see below) following the appropriate technique, with adequate hand drying.

### **Types of Skin Flora [6, 10, 81, 83]**

The main types of microbial flora on the skin are resident (normal) flora and the transient flora. Most of the hand flora are found under and around the fingernails.

## ***Resident Flora***

Consists of microorganisms that normally reside on the skin. They may include bacteria and fungi, but viruses are not usually a part of resident flora.

They are mainly attached to deeper layers of the skin and are less likely to be associated with health-care–associated infections. They are not regarded as pathogens on intact skin but may cause infections in the eyes, or on nonintact skin.

Resident flora are more resistant to removal than transient flora (see below). They are difficult to be removed mechanically, but hand washing may reduce their numbers. And if disrupted by hand hygiene methods, they re-establish themselves at the same site on the skin.

This normal resident flora serves a protective function against colonization by pathogenic microorganisms. Long-term changes may occur to resident flora after contact with disinfectants, antibiotics therapy, or disease.

## ***Transient Flora***

Consists of microorganisms that may be found on the skin only at times, and occasionally multiply and cause disease. They may come from patients (blood, saliva, or dental plaque) or inanimate surfaces. They colonize the superficial layers of the skin and are the organisms most often associated with health-care–associated infections.

They are easier to be removed mechanically by routine hand washing or by other proper hand hygiene practices than resident flora.

## **Hand Hygiene Methods and Indications** **[6, 10, 81, 83-86]**

The preferred method for hand hygiene depends on the type of procedure, the degree of contamination, and the desired persistence of antimicrobial action on the skin.

Hand hygiene methods and their indications within the clinic are listed in Table 9. From the table, it may be summarized that for routine



dental examinations and nonsurgical procedures, handwashing and hand antiseptics is achieved by using either a plain or antimicrobial soap and water. If the hands are not visibly soiled, an alcohol-based hand rub is adequate.

Furthermore, the following should be taken into consideration when choosing the method of hand hygiene:

1. If the hands are known to be or are suspected of being contaminated, an antiseptic hand wash or antiseptic hand rub (after washing off visible soil) should be performed with an antiseptic which has bactericidal, fungicidal, and virucidal (coated viruses) activity.
2. Residual powder left on the hands by powdered gloves may interfere with the antimicrobial action of alcohol based products. Therefore, if alcohol based products are to be used following removal of gloves, powder-free gloves should be used.
3. Antimicrobial-impregnated wipes may be considered as an alternative to washing hands with plain soap and water, in the absence of visible debris. However, such wipes should not be used as a substitute for using an alcohol-based hand rub or antimicrobial soap because they are not as effective for reducing bacterial counts on the hands of HCP.
4. However, if exposure to bacterial spores is suspected or proven, hands should be washed with soap (antimicrobial or plain) and water. The physical action of washing and rinsing hands under such circumstances is recommended because alcohols, and other antiseptic agents have poor activity against spores.
5. Also, the following non-clinical situations are all indications for washing hands with soap (antimicrobial or plain) and water:
  - a. Before preparing or eating food.
  - b. After going to the bathroom.
  - c. After handling uncooked foods, particularly raw meat, poultry, or fish.

- d. After blowing the nose, coughing, or sneezing.
- e. After handling an animal or animal waste.
- f. After handling garbage.
- g. Before and after treating a cut or wound.
- h. After handling items contaminated by sewage.

**Table 9**

*Hand Hygiene Methods and Indications Within the Clinic*

Method	Agent	Purpose	Duration (minimum)	Indication
Routine handwash	Water and plain soap	Remove soil and transient micro-organisms	15 seconds	<ul style="list-style-type: none"> <li>•Before and after contacting or treating each patient (e.g. before glove placement and after glove removal).</li> <li>•After barehanded touching of inanimate objects likely to be contaminated by blood or saliva.</li> </ul>
Antiseptic handwash	Water and antimicrobial soap (e.g. chlorhexidine, iodine and iodophors, chloroxylenol [PCMX], triclosan)	Remove or destroy transient micro-organisms and reduce resident flora	15 seconds	<ul style="list-style-type: none"> <li>•Before leaving the dental operatory or the dental laboratory.</li> <li>•When hands are visibly soiled (but alcohol hand rubs not indicated in this situation).</li> </ul>
Antiseptic hand rub	Alcohol-based hand rub <sup>††</sup>	Remove or destroy transient micro-organisms and reduce resident flora	Rub hands until the agent is dry	<ul style="list-style-type: none"> <li>•Before regloving after removing gloves that are torn, cut or punctured.</li> </ul>

Surgical antiseptics	Water and antimicrobial soap (e.g. chlorhexidine, iodine and iodophors, chloroxylenol [PCMX], triclosan)  Water and plain soap followed by an alcohol-based surgical hand-scrub product with persistent activity	Remove or destroy transient microorganisms and reduce resident flora (persistent effect)	2-6 minutes  Follow manufacturer instructions for surgical hand-scrub product with persistent activity	Before donning sterile surgeon's gloves for the following procedures:  •biopsy •periodontal surgery •apical surgery •implant surgery •surgical extraction of teeth
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Source: CDC [10], and CDC [81]

The following is an outline of the effects, advantages, disadvantages, and technique for the various hand hygiene methods.

### **Hand washing**

Washing the hands with unmedicated soap and water removes dirt and loosely adhering microbial skin flora (most of the transient and a small part of the resident flora) through the physical action of scrubbing the skin in the presence of a detergent. However, handwashing with plain soap does not inactivate the microorganisms. This method does not guarantee prevention of hand transmission of microorganisms.

The cleaning efficiency depends on the time and technique of washing. Scrubbing the hands with the cleaning agent should be performed for 15-20 seconds, and the whole procedure should not take less than 30 seconds.

#### **Advantages:**

1. Can use plain soap
2. Effectiveness not affected by organic matter.
3. Familiar technique

#### **Disadvantages:**

1. Frequent handwashing with soaps and antiseptic agents (or

- even with water alone) can cause chronic irritant contact dermatitis.
- a. Skin damage causes changes in skin flora, resulting in more frequent bacterial colonization (staphylococci and gram-negative bacteria).
  - b. Adding emollients to the detergents reduce skin damage.
  - c. Water-based lotions recommended to ease the dryness resulting from frequent handwashing and to prevent dermatitis from glove use.
  - d. Petroleum-based lotions can weaken latex gloves and increase permeability, thus should only be used at the end of the work day.
  - e. Using hot water leads to greater skin irritation and scaling of the skin, which may be due to increased penetration of detergents into the epidermis.
2. Compliance with recommended handwashing protocol is traditionally low.
  3. Requires fully equipped handwashing facilities.
  4. Takes more time than antiseptic hand rubs.
  5. Time and technique are critical.
  6. Strong fragrances and other ingredients may be poorly tolerated by some HCP.
  7. Washing with non-medicated soap may lead to contamination of hands by the washing process per se.
    - a. A possible source is the sink itself, when splashes of contaminated water come in contact with the hand of the health care worker. The reason is that the microorganisms are not killed during the hand wash but only removed and distributed in the immediate surroundings of the person, including the clothes.
    - b. Also, occasionally, plain soaps may become contaminated, which may lead to colonization of hands of personnel with gram-negative bacilli.

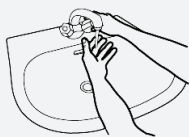
## Technique:

1. Remove jewelry (rings and watches).
2. Adjust the water flow and temperature.
3. Wet hands with water.
4. Apply an amount of product recommended by the manufacturer to hands.
5. Rub hands together vigorously, without splashing, for at least 15 seconds covering all surfaces of the hands and fingers (see Figure 1 for technique to ensure all surfaces are covered).
6. Rinse hands with water.
7. Dry hands thoroughly with a disposable towel.
8. Use towel to turn off the faucet.
9. Apply hand lotion as necessary.

**Figure 1**

*Technique for Rubbing Hands During Handwashing*

**0**



Wet hands with water;

**1**



Apply enough soap to cover all hand surfaces;

**2**



Rub hands palm to palm;

**3**



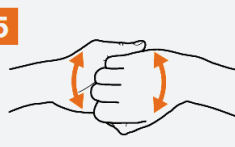
Right palm over left dorsum with interlaced fingers and vice versa;

**4**



Palm to palm with fingers interlaced;

**5**



Backs of fingers to opposing palms with fingers interlocked;

**6**



Rotational rubbing of left thumb clasped in right palm and vice versa;

**7**



Rotational rubbing, backwards and forwards with clasped fingers of right hand in left palm and vice versa;

**8**



Rinse hands with water;

*Source: WHO [86]*

### ***Requirements of Handwashing Facilities:***

1. Wash basin should be placed in a convenient place to increase the compliance.
2. Sinks should be constructed of a smooth, highly polished material, such as stainless steel or porcelain, which is amenable to repeated disinfection procedures.
3. Sinks should be large enough and faucets placed in such a way to allow washing of hands without contacting the faucet or sink.
4. Faucet controls, soap and lotion dispensers, should allow hands-free operation so as to avoid their contamination by unwashed hands. Sensor-operated or foot controls may be utilized as well as elbow-controlled faucet handles.
5. A mixer tap helps to provide comfortable temperature.
6. Liquid soap dispensers should be either disposable or easily removable and heat resistant for thermal reprocessing.
7. Liquid soap from refillable containers should be bacteriostatic to prevent microbial growth.
8. Soap should not be added to a partially empty dispenser, because this can lead to bacterial contamination of the soap.
9. For plain soap, the following forms are acceptable: liquid, leaflet or powdered forms.
10. Products should be stored and dispensed according to the manufacturers' directions
11. Paper towel dispensers should be designed and positioned to allow paper towels to be pulled out individually without contamination of the dispenser or the remaining contents.
12. There must be a container for used towels.

### ***Antiseptic Hand Rub***

The objective of this method is to reduce the microbial release with maximum efficiency and speed.

Alcohol hand rubs are rapidly germicidal when applied to the skin. So the agent of choice for waterless hand rubs should be alcohol based

(60%–95% ethanol or isopropanol) and should not be used in the presence of visible soil or organic material. Alcohol formulations which contain chlorhexidine, quaternary ammonium compounds, octenidine, or triclosan should be used if persistent activity is required.

In the absence of visible soil, it is acceptable to apply waterless handrubs repeatedly without washing hands with soap and water. However, washing hands is recommended after 5-10 applications because of buildup of the handrub product.

Repeated use of an alcohol hand rub may cause some dryness of the skin. However, such dryness is significantly less than that caused by washing hands with detergent. Furthermore, the drying effect of alcohol can be reduced or eliminated by adding 1%–3% glycerol or other skin-conditioning agents.

### ***Advantages:***

- Alcohol based antiseptic hand-rubs provide more effective antiseptic action on visibly clean hands than washing with plain or antimicrobial soaps.
- Faster protocol than the handwashing protocol.
- May be used without handwashing facilities.
- Allergic reactions rare.

### ***Disadvantages:***

- Not indicated when hands visibly soiled.
- Frequent use may cause skin dryness or irritation if product lacks effective emollients/skin conditioners.
- Agent may temporarily sting compromised skin.
- Strong fragrances may be poorly tolerated by some HCP.
- Alcohol products are flammable, so should be stored away from flames.
- Residual powders following removal of powdered gloves may interfere with effectiveness of antiseptic rub.
- Handwashing stations must still be accessible for times when

the use of waterless sanitizers are not appropriate.

**Technique:**

1. Hands must be dry before agent is applied.
2. The manufacturer's recommendations should be followed regarding the volume of product to use.
3. The product should be applied to the palm of one hand and the hands rubbed together, covering all surfaces of hands and fingers, until hands are dry.
4. If hands feel dry after rubbing them together for 10–15 seconds, an insufficient volume of product likely was applied.

***Antiseptic Hand Wash***

The aim of this method is to reduce the microbial release using a washing procedure that is more effective than ordinary hand washing. The washing technique is illustrated in Figure 1. Agents to be used depend on the use (similar to hygienic rub). The most commonly used are detergent preparations containing iodophors, chlorahexidine glucnate, triclosan.

Alcohol-based products are more effective for use in antiseptic handwashes than other antimicrobial formulations.

***Surgical Hand Disinfection***

The invasive nature of the following oral procedures: biopsy, periodontal surgery, apical surgery, implant surgery, and surgical extraction of teeth, indicates a need for a heightened level of pre-operative hand hygiene for DHCP. The objective of surgical hand disinfection is to reduce the release of skin bacteria (transient and resident flora) from the hands of the surgical team for the duration of an operation in case the surgical glove is punctured or torn. Thus, agents used for surgical hand antisepsis must be fast-acting, and have a persistent effect. They should also substantially reduce microorganisms on intact skin, contain a nonirritating antimicrobial preparation, and have a broad spectrum of activity.

The recommended protocol for surgical hand antisepsis involves either:



- a. Water and anti-microbial soap, or
- b. Water and plain soap followed by an alcohol-based surgical hand-scrub product with persistent activity.

The most active agents in reducing microbial counts post-scrubbing are formulations containing 60%–95% alcohol alone or 50%–95% when combined with limited amounts of a quaternary ammonium compound, hexachlorophene, or chlorhexidine gluconate. The next most active agents (in order of decreasing activity) are chlorhexidine gluconate, iodophors, triclosan, and plain soap.

Hexachlorophene is absorbed into the blood after repeated use, therefore it should not be used as a surgical scrub.

**Technique:**

1. Remove rings, watches, and bracelets before beginning the surgical hand scrub.
2. Remove debris from underneath fingernails using a nail cleaner under running water.
3. If using an antimicrobial soap:
  - a. Scrub hands and forearms for the length of time recommended by the manufacturer, usually 2–6 minutes.
  - b. Fingertips should always point upward, with elbows down, to avoid recontamination of clean fingers and hands by water running down from contaminated proximal areas.
  - c. Long scrub times (e.g., 10 minutes) are not necessary and frequently lead to skin damage.
  - d. Dry hands well using sterile towels, starting at the tips of the fingers, followed by the hands, then the forearms.
4. If using an alcohol-based surgical hand-scrub product with persistent activity:
  - a. Before applying the alcohol solution, prewash hands and forearms with either plain or antimicrobial soap (4% chlorhexidine gluconate or povidone-iodine) for 1- or 2-minutes, taking care that fingertips point upward.

- b. After washing, dry hands and forearms completely.
  - c. Apply the alcohol-based product as recommended by the manufacturer.
  - d. Rub the product onto the entire surface of the fingertips, hands and forearms, keeping them wet for the recommended time by adding further portions as necessary, and carrying out wash movements.
  - e. A hand rub should never be followed by a hand wash, because this has been shown to considerably lessen the effect of the rub.
  - f. Allow hands and forearms to dry thoroughly before donning sterile gloves.
5. Scrubbing with a brush is not recommended as it can damage the skin of personnel and result in increased shedding of bacteria from the hand.

### **Selection of Hand Hygiene Agents [6, 10, 81]**

Only hand hygiene products approved by the FDA should be used. And when selecting from FDA approved products, selection should be based on the kind of procedure being done and the level of exposure anticipated. Personnel should be provided with hand hygiene products with appropriate spectrum of activity for their intended use. Persistence of activity and speed of activity must also be taken into consideration when selecting a product. Delivery system, reliable vendor support and supply are also considerations. Low irritancy potential of an agent also must be sought, particularly when these products are used multiple times per shift. The cost of hand hygiene products should not be the primary factor influencing product selection.

Because HCP acceptance is a major factor regarding compliance with recommended hand hygiene protocols, end users should have an input during evaluation and selection of hand-hygiene products. Such input should include possible chemical allergies, skin integrity after repeated use, compatibility with lotions used, and offensive agent ingredients (e.g., scent).

When selecting hand hygiene agents, information should be obtained from manufacturers regarding any known interactions between products used to clean hands, skin care products, and the types of gloves used. Also, the dispenser systems of the various products should be evaluated to ensure that dispensers function adequately and deliver an appropriate volume of product.

Also, lotions or creams should be provided for HCP to minimize the occurrence of irritant contact dermatitis associated with hand antiseptics or handwashing. Information should be obtained from manufacturers regarding any effects that hand lotions, creams, or alcohol-based hand antiseptics may have on the persistent effects of antimicrobial soaps being used.

### **Storage of Hand Hygiene Products [81]**

Hand hygiene products should be stored in closed containers which are either disposable, or that can be washed and dried before refilling. Fresh products should never be added to remaining amounts within the container, due to the possibility of contamination and overgrowth of microorganisms.

Supplies of alcohol-based hand rubs should be stored in cabinets or areas approved for flammable materials.

### **Agents Used for Hand Hygiene [10, 81, 83]**

#### ***Plain (Non-Antimicrobial) Soap***

Soaps are detergent-based products that are available in various forms. Their cleaning activity can be attributed to their detergent properties, which result in removal of dirt, soil, and various organic substances from the hands. Plain soaps have minimal, if any, antimicrobial activity. Handwashing with plain soap can remove loosely adherent transient flora. However, in several studies, handwashing with plain soap failed to remove pathogens from the hands of hospital personnel.

#### ***Effect on human skin:***

Non-antimicrobial soaps may be associated with considerable skin

irritation and dryness, although adding emollients to soap preparations may reduce their propensity to cause irritation.

A single hand wash already significantly reduces the dermal sebum content; the reduction lasts for 1 h. If hands are washed four times within 1 h, the skin does not recover to its normal state within this period. Frequent hand washing induces irritative contact dermatitis (ICD) and dry skin, which may become colonized with nosocomial pathogens.

Furthermore, each hand wash detrimentally alters the water-lipid layer of the superficial skin, resulting in a loss of various protective agents such as antimicrobial protective factors. Regeneration of the protective film may be insufficient if many hand washes are carried out in a row. This may lead to damage of the barrier function of the stratum corneum, the transepidermal water loss (TEWL) increases, and the skin becomes more permeable for toxic agents.

### ***Alcohols***

The majority of alcohol-based hand antiseptics contain either isopropanol, ethanol, n-propanol, or a combination. N-propanol is not an FDA-approved active agent for HCP hand washes or surgical hand-scrub preparations. The antimicrobial activity of alcohols can be attributed to their ability to denature proteins. Alcohol solutions containing 60%--95% alcohol are most effective. Higher concentrations are less potent because proteins are not denatured easily in the absence of water.

Alcohol hand rubs are rapidly germicidal when applied to the skin; and the regrowth of bacteria on the skin after use of alcohol-based hand antiseptics is slow. So the agent of choice for waterless hand rubs should be alcohol based. However, alcohols have no persistent activity; therefore, such hand rubs should include other antiseptics such as chlorhexidine, quaternary ammonium compounds, octenidine, or triclosan to achieve persistent activity.

#### ***Effect on micro-organisms:***

Alcohols have excellent in vitro germicidal activity against gram-positive and gram-negative vegetative bacteria, including multidrug-resistant pathogens, *Mycobacterium tuberculosis*, and various fungi. Cer-

tain enveloped (lipophilic) viruses (e.g., herpes simplex virus, human immunodeficiency virus [HIV], influenza virus and respiratory virus are susceptible to alcohols. Hepatitis B virus is somewhat less susceptible but is killed by 60%–70% alcohol. Hepatitis C virus also is likely killed by this percentage of alcohol. Alcohols have very poor activity against bacterial spores and some non-enveloped (non-lipophilic) viruses.

In the presence of heavy microbial contamination (without visible debris or proteinaceous material) an antiseptic hand rub using an alcohol-based rinse may be more effective at preventing pathogen transmission than handwashing with plain soap and water. Also, alcohol-based products are more effective for standard handwashing or hand antisepsis by HCP than soap or other antimicrobial soaps.

Ethanol 60%–95% is classified by the FDA as a Category I agent (i.e., generally safe and effective for use in antiseptic handwash or HCP hand-wash products). However, isopropanol 70%–91.3% was classified as category IIIE (i.e., insufficient data to classify as effective).

Alcohols are effective for preoperative cleaning of the hands of surgical personnel. The majority of alcohol-based preparations have been found to be more effective than povidone-iodine or chlorhexidine. No acquired bacterial resistance to alcohols has been reported to date.

The efficacy of alcohol-based hand-hygiene products is affected by several factors :

- Type of alcohol used.
- Concentration of alcohol.
- Contact time.
- Whether the hands are wet when the alcohol is applied.
- Volume of alcohol used: Applying small volumes (i.e., 0.2–0.5 ml) of alcohol to the hands is not effective. The ideal volume of product to apply to the hands is not known and may vary for different formulations. However, if hands feel dry after rubbing hands together for 10-15 seconds, an insufficient volume of product likely was applied. Because alcohol-impregnated towelettes contain a limited amount of alcohol, their effectiveness

is comparable to that of soap and water.

### ***Effect on skin :***

Alcohols are considered to be among the safest antiseptics available and generally have no toxic effect on human skin. The skin barrier remains intact, dermal hydration does not change significantly, and the dermal sebum content remains unchanged.

Repeated exposure to alcohol or a moderately formulated product can cause or maintain skin dryness and irritation. Adding glycerol, humectants, emollients, or other skin-conditioning agents can reduce or eliminate the drying effects of alcohol. Alcohol-based hand rubs containing emollients may cause significantly less skin dryness and irritation than washing hands with liquid detergents.

When alcohol-based hand rubs are used following prolonged periods of hand washing with plain soap or antimicrobial soap and water, burning or stinging of the skin may be experienced when applying the alcohol. This is usually due to the presence of underlying, detergent-associated irritant contact dermatitis (ICD). Skin that has been damaged by preexisting exposure to detergents may be more susceptible to irritation by alcohols than are non-damaged skin areas. As the skin condition improves with continued use of alcohol-based hand rubs, the burning and stinging associated with applying alcohol invariably disappears.

Allergic reactions to alcohols are very rare.

### ***Disadvantages:***

- Organic matter diminishes the antimicrobial activity of alcohols slightly. Alcohols are not appropriate for use when hands are visibly dirty or contaminated with proteinaceous materials.
- Alcohols are flammable and require special storage conditions for liquids with flash points ranging between 21°C- 24°C (“easily flammable”). Handling items such as polyester may create a substantial amount of static electricity which could ignite unevaporated alcohol, therefore hands should be rubbed together after application of alcohol-based products until all the

alcohol has evaporated.

- Frequent use of alcohol-based formulations for hand antisepsis can cause drying of the skin unless emollients, humectants, or other skin-conditioning agents are added to the formulations. The drying effect of alcohol can be reduced or eliminated by adding 1%--3% glycerol or other skin-conditioning agents.
- Alcohol hand rubs containing emollients may cause a transient stinging sensation at the site of any broken skin (e.g., cuts and abrasions).
- Alcohol-based hand-rub preparations with strong fragrances may be poorly tolerated by HCP with respiratory allergies.
- Allergic contact dermatitis or contact urticaria syndrome caused by hypersensitivity to alcohol or to various additives present in certain alcohol hand rubs (occurs only rarely).
- Alcohols are volatile, therefore containers should be designed to minimize evaporation.
- Residual powder left on the hands by powdered gloves may interfere with the antimicrobial action of alcohol based products. Therefore, if alcohol based products are to be used following removal of gloves, powder-free gloves should be used.

### ***Chlorhexidine***

Chlorhexidine gluconate is commonly used either at 0.5 to 0.75% in aqueous solutions and detergent preparations or at 2 to 4% in other detergent preparations.

Chlorhexidine's antimicrobial activity is slower than that of alcohols, but it seems to have good residual activity. Its residual effect is probably the best of any antiseptic available. Thus, it has been added to alcohol-based preparations for surgical hand disinfection to extend the antimicrobial activity of alcohols under the glove.

#### ***Effect on micro-organisms:***

The antimicrobial activity of chlorhexidine is likely attributable to at-

tachment to, and subsequent disruption of, cytoplasmic membranes, resulting in precipitation or coagulation of cellular contents. Chlorhexidine also prevents the outgrowth, but not the germination, of bacterial spores.

The antimicrobial activity of chlorhexidine is dependent on its concentration. When used in a liquid soap, chlorhexidine usually has a concentration of 4% and exhibits a bactericidal activity against various gram-positive and, to a lesser extent, gram-negative bacteria and fungi. It has only minimal activity against tubercle bacilli. Chlorhexidine is not sporicidal. It is active against enveloped viruses (e.g., herpes simplex virus, HIV, cytomegalovirus, influenza, and RSV) but substantially less activity against nonenveloped viruses.

In a comparison with a nonmedicated hand wash product, a chlorhexidine-based scrub yielded a lower reduction of different antibiotic-resistant bacteria such as MRSA and vancomycin resistant enterococci (VRE). Furthermore, chlorhexidine has been described to be less effective in vitro against various nosocomial pathogens than is benzalkonium chloride or povidone iodine.

Recurrent exposure of bacteria to chlorhexidine may lead to adaptation and may enhance their resistance. The potential for cross-resistance between antiseptic agents and antibiotics must be given careful consideration. Resistance to chlorhexidine may even result in nosocomial infections. Occasional outbreaks of nosocomial infections have been traced to contaminated solutions of chlorhexidine.

### ***Effect on Skin :***

When used as recommended, chlorhexidine is safe for the skin. Detergents containing chlorhexidine were reported to cause skin damage less frequently than was nonantimicrobial soap or other detergents containing antimicrobial agents. However, skin irritation may occur with high-concentration products (containing 4%) when used frequently for antiseptic handwashing.

Allergic reactions to chlorhexidine gluconate are uncommon. However, there is a potential for sensitization and allergic contact derma-



titis during frequent use of chlorhexidine. Allergic reactions to the use of detergents containing chlorhexidine gluconate on intact skin have been reported and can be severe, including dyspnea and anaphylactic shock. Some cases of contact urticaria have also occurred as a result of chlorhexidine use.

Furthermore, care must be taken to avoid contact with the eyes when using preparations >1% chlorhexidine, because the agent can cause conjunctivitis and severe corneal damage.

***Disadvantages:***

- The antimicrobial activity of chlorhexidine can be reduced by natural soaps, various inorganic anions, nonionic surfactants, and hand creams containing anionic emulsifying agents.
- Inactivation of chlorhexidine may result in contamination of solutions containing 0.1% chlorhexidine.
- Chlorhexidine's antimicrobial activity is slower than that of alcohols.
- Recurrent exposure of bacteria to chlorhexidine may enhance their resistance.
- Resistance to chlorhexidine may even result in nosocomial infections. Occasional outbreaks of nosocomial infections have been traced to contaminated solutions of chlorhexidine.
- The use of detergents containing chlorhexidine gluconate can cause allergic reactions on the skin which can be severe.
- Preparations containing more than 1% chlorhexidine can cause conjunctivitis and severe corneal damage when come in contact with eye.

***Iodine and Iodophors***

Iodine is an effective antiseptic. However, iodine often causes irritation and discoloring of skin, therefore, iodophors have replaced iodine as the active ingredient in antiseptics. Povidone-iodine 5%–10% has been tentatively classified by FDA TFM as a Category I agent (i.e., a safe and effective agent for use as an antiseptic handwash and an

HCP handwash).

The amount of molecular iodine present (so-called “free” iodine) determines the level of antimicrobial activity of iodophors. Combining iodine with various polymers increases the solubility of iodine, promotes sustained release of iodine, and reduces skin irritation.

### ***Effect on Micro-organisms:***

The antimicrobial spectrum of iodine preparations is wide, even including bacterial spores. Efficacy against spores is too slow to be useful in hand disinfection. Iodine and iodophors have bactericidal activity against gram-positive, gram-negative, and certain spore-forming bacteria (e.g., clostridia and *Bacillus* spp.) and are active against mycobacteria, viruses, and fungi. However, in concentrations used in antiseptics, iodophors are not usually sporicidal.

An aqueous solution of povidone-iodine, the most commonly used iodophor, is approximately as effective in reducing skin flora as 60% isopropanol, but preparations in liquid soap are much less active. The majority of iodophor preparations used for hand hygiene contain 7.5%-10% povidone-iodine. Lower concentrations also have good antimicrobial activity because dilution can increase free iodine concentrations. However, as the amount of free iodine increases, the degree of skin irritation also may increase.

The sustained effect is short.

The antimicrobial activity of iodophors is substantially reduced in the presence of organic substances (e.g., blood or sputum). Organic matter reduces antimicrobial activity slightly, but blood may abolish the antimicrobial effect. The antimicrobial activity of iodophors also can be affected by pH, temperature, exposure time, concentration of total available iodine, and the amount and type of organic and inorganic compounds present (e.g., alcohols and detergents). Unless special precautions are taken, the antimicrobial efficacy of povidone preparations wanes during storage.

Iodophor antiseptics may become contaminated with gram-negative bacilli as a result of poor manufacturing processes.

### ***Effect on Skin:***

Iodine is absorbed through the intact skin across mucous membranes, the use of iodine-containing preparations may be associated with undesired side effects such as allergic reactions. Skin irritation and damage occur rather often and may thus adversely influence compliance with hand disinfection. Iodophors cause more irritant contact dermatitis than other antiseptics commonly used for hand hygiene.

### ***Disadvantages:***

- The antimicrobial activity of iodophors is affected by organic substances (e.g., blood or sputum), pH, temperature, exposure time, concentration of total available iodine, and the amount and type of organic and inorganic compounds present (e.g., alcohols and detergents).
- The antimicrobial efficacy of povidone preparations might wane during storage.
- Iodine often causes skin irritation and damage and iodophors cause more irritant contact dermatitis than other antiseptics.

### ***Quaternary Ammonium Compounds***

Quaternary ammonium compounds are a large group of compounds which vary in their structure and complexity, but derive their name from their shared chemical composition of a nitrogen atom linked to four alkyl groups. Of these compounds, alkyl benzalkonium chlorides are the most widely used as antiseptics. Other compounds that have been used as antiseptics include benzethonium chloride, cetrimide, and cetylpyridium chloride.

FDA tentatively classifies benzalkonium chloride and benzethonium chloride as Category III SE active agents (i.e., insufficient data exists to classify them as safe and effective for use as an antiseptic hand-wash).

For skin and hand disinfection quaternary ammonium compounds present are in combination with other antiseptics such as alcohols. They are not compatible with anionic detergents.

### ***Effect on Micro-organisms:***

Quaternary ammonium compounds are mainly bacteriostatic and fungistatic and microbiocidal in high concentrations. They are more active against gram-positive bacteria than against gram-negative bacilli. They have weak activity against mycobacteria and fungi, but are active against some viruses (lipophilic viruses), especially in combination with alcohols.

Because of weak activity against gram-negative bacteria, benzalkonium chloride is prone to contamination by these organisms.

Their antimicrobial activity is adversely affected by the presence of organic material and ion-rich water.

### ***Effect on Skin:***

Quaternary ammonium compounds have low allergenic and toxicity potentials, but are three to ten times higher than the phenols derivatives.

### ***Disadvantages:***

- Quaternary ammonium compounds have weak activity against gram-negative bacteria and they are prone to contamination by these organisms.
- Their antimicrobial activity is affected by the presence of organic material and ion-rich water.

## ***Triclosan***

Triclosan is an antimicrobial incorporated into soaps for use by HCP and the public. The commonly used concentration in antiseptic soaps is 1%. The FDA TFM tentatively classified triclosan <1.0% as a Category III SE active agent (i.e., insufficient data exist to classify this agent as safe and effective for use as an antiseptic handwash).

### ***Effect on Micro-organisms:***

Triclosan achieves its antimicrobial effect by blocking lipid synthesis. It has a broad range of antimicrobial activity, but it is often bacteriostatic. Triclosan's activity against gram-positive organisms (including

MRSA) is greater than against gram-negative bacilli. The agent possesses reasonable activity against mycobacterial and *Candida* spp., but it has limited activity against filamentous fungi.

Triclosan has persistent activity on the skin. However, it has been shown to be less effective at microbial reduction compared to chlorhexidine, iodophors, or alcohol-based products. The amount of bacterial reduction achieved with triclosan appear to be similar to that achieved with nonmedicated soap. Furthermore, microbial resistance to triclosan is of concern, with evidence of microorganisms developing multi-resistance to various antibiotics following exposure to triclosan.

Triclosan's activity is not substantially affected by organic matter, but it can be inhibited by surfactants present in certain formulations. Furthermore, triclosan's lack of potent activity against gram-negative bacilli has resulted in occasional reports of contamination.

### ***Effect on skin:***

The majority of formulations containing <2% triclosan are well-tolerated and seldom cause allergic reactions.

### ***Disadvantages:***

- The amount of bacterial reduction achieved with triclosan is less than that achieved with chlorhexidine, iodophors, or alcohol-based products.
- Triclosan lack potent activity against gram-negative bacteria and they are prone to contamination by these organisms.
- Their antimicrobial activity can be inhibited by surfactants present in certain formulations.
- There is evidence of microorganisms developing multi-resistance to various antibiotics following exposure to triclosan.

Table 10 is a summary of the antimicrobial spectrum of selected hand hygiene agents.

**Table 10**

*Anti-microbial Spectrum of Selected Hand Hygiene Agents*

AGENT	Gram-Positive Bacteria	Gram-Negative Bacteria	Mycobacteria	Fungi	Viruses	Speed of Action	Comments
Alcohols	+++	+++	+++	+++	+++	Fast	Optimum concentration 60%-95%; no persistent activity
Chlorhexidine (2% and 4%)	+++	++	+	+	+++	Intermediate	Persistent activity, rare allergic reactions
Iodophors	+++	+++	+	++	++	Intermediate	Less irritation than iodine
Phenolics	+++	+	+	+	+	Intermediate	Neutralized by non-ionic surfactants
Triclosan	+++	++	+	-	+++	Intermediate	Acceptability on hands varies
Quaternary ammonium compounds	+	++	-	-	+	Slow	Used only in combination with alcohols

+++ Excellent

++ Good but does not include the entire bacterial spectrum

+ Fair

- No activity

Source: adapted from CDC [81]

## Skin Reactions to Hand Hygiene Products [81]

### ***Irritant Contact Dermatitis***

Frequent and repeated use of hand-hygiene products, particularly soaps and other detergents, is a primary cause of chronic irritant contact dermatitis among HCP. Affected persons often complain of a feeling of dryness or burning; skin that feels “rough;” and erythema, scaling, or fissures. Such damage to the skin may change skin flora, resulting in more frequent colonization by staphylococci and gram-negative bacilli.

Iodophors are the most commonly reported antiseptic causing irritant contact dermatitis. Other antiseptic agents that can cause irritant contact dermatitis (in order of decreasing frequency) include chlorhexidine, triclosan, and alcohol-based products. Skin that is damaged by repeated exposure to detergents may be more susceptible to irritation by alcohol-based preparations. Routinely washing hands with soap and water immediately after using an alcohol hand rub may also lead to dermatitis.

Other factors that can contribute to dermatitis associated with frequent handwashing include using hot water for handwashing, low relative humidity (most common in winter months), failure to use supplementary hand lotion or cream, and the quality of paper towels. Shear forces associated with wearing or removing gloves and allergy to latex proteins may also contribute to dermatitis of the hands of HCP.

Irritant contact dermatitis may be reduced by replacing products with high irritation potential with preparations that cause less damage to the skin. Exposure of personnel to irritating soaps and detergents may be reduced through the use of alcohol-based hand rubs containing various emollients. Also, HCP may be educating regarding the risks of irritant contact dermatitis, and provided with moisturizing skin-care products. Regular use (e.g., twice a day) of moisturizers can help prevent and treat irritant contact dermatitis caused by hand-hygiene products.

### ***Allergic Contact Dermatitis***

Liquid soaps and hand lotions or creams may contain ingredients that cause contact allergies among HCP. Allergic reactions to products

applied to the skin (i.e., contact allergies) may present as delayed type reactions (i.e., allergic contact dermatitis) or less commonly as immediate reactions (i.e., contact urticaria).

Allergic contact dermatitis associated with alcohol-based hand rubs is uncommon. Allergic reactions to alcohol-based products may represent true allergy to alcohol or may be caused by compounds that may be present as inactive ingredients in alcohol-based hand rubs.

## **Other Hand Hygiene Considerations [6, 10, 81]**

### ***Fingernails***

Subungual areas (areas beneath the nails) of the hand harbor high concentrations of bacteria. Even after careful handwashing or the use of surgical scrubs, personnel often harbor substantial numbers of potential pathogens in the subungual spaces. And although freshly applied nail polish does not increase the number of bacteria recovered from the skin around the nails, chipped nail polish may support the growth of larger numbers of organisms on fingernails.

Therefore, fingernails should be kept short with smooth, filed edges to allow the skin beneath the nails to be cleaned with routine handwashing, and prevent glove tears. Furthermore, artificial fingernails should not be worn.

### ***Jewelry***

Rings, watches, and bracelets should be removed prior to hand hygiene and should not be worn if they make donning gloves more difficult or compromises the fit and integrity of the glove.



## PERSONAL PROTECTIVE EQUIPMENT

[2, 5-6, 10, 13, 81, 87-93]

Personal protective equipment (PPE) such as protective clothing and eyewear, face shields and disposable gloves are designed to protect the skin and mucous membranes of the eyes, nose, and mouth of dental healthcare practitioners. Therefore, they are worn as a barrier to prevent the transmission of microorganisms between patients and the dental team. Gloves also reduce the likelihood that microorganisms present on DHCP hands will be transmitted to patients during surgery or patient-care procedures.

PPE must be easily accessible for DHCP and should be stored in clean areas away from potential contamination. Contaminated PPE should be disposed of as hazardous dental healthcare waste.

### Gloves

Gloves protect DHCP from direct contact with microorganisms present in the patient's mouth and on contaminated surfaces. Also, they protect patients from microorganisms on the hands of the dental team.

#### ***Indications of Wearing Gloves***

1. To provide a barrier to protect the wearer from contamination when a potential exists for contacting patient's blood, saliva, mucous membranes, or other potentially infectious materials.
2. To reduce the risk of transmission of microbes from dentist to patient
3. Gloves should be worn for all routine dental treatment and discarded between patients
4. Preventing heavy contamination of the hands through use of gloves is considered important, because handwashing or hand antisepsis may not remove all potential pathogens when hands are heavily contaminated.

#### ***Precautions to be Taken When Wearing Gloves***

1. Fingernails should be short

2. Hands must be washed immediately before donning gloves. Never consider gloves to be an alternative to hand washing.
3. Use of petroleum-based hand lotions or creams may adversely affect the integrity of latex gloves.
4. After a hand rub with alcohol, the hands should be thoroughly dried before gloving, because hands still wet with an alcohol-based hand hygiene product can increase the risk of glove perforation.
5. Never re-use single use disposable gloves.
6. Changing gloves between patients prevents cross-infection between patients and contamination of hard surfaces in the surgery.
7. Gloves should be changed during patient care if the hands will move from a contaminated body site to a clean body site.
8. Unprotected surfaces such as patients' files, pens, telephones, computer keyboards, door or drawer handles, or face should not be touched with gloved hands.
9. Gloves that are torn, cut or punctured should be removed as soon as feasible, and hands washed before re-gloving.
10. Gloves should be changed during very long procedures, as up to 40% of gloves develop tears after prolonged use and may leak. Gloves also become porous during prolonged use due to hydration of the latex. Also, by changing gloves excess sweating can be prevented, reducing the risk of dermal infections or inflammation.
11. Gloves must only be worn whilst treating the patient and removed at the end of the procedure and should be disposed of as hazardous waste.
12. Gloves should not be washed, and no attempts should be made to disinfect or sterilize gloves.
13. Hands should not be considered clean because gloves have been worn.
  - a. Gloves do not provide complete protection against hand contamination. Bacterial flora colonizing patients may be

recovered from the hands of < 30% of HCP who wear gloves during patient contact.

- b. When removing gloves the patient's microorganisms can be transmitted from the external surface of the glove to the dentist's hands and need to be removed by hand hygiene.
14. Gloves do not prevent sharps injuries.

### ***Choosing a Suitable Glove for the Task***

Disposable gloves are manufactured in a variety of materials and must conform to acceptable safety levels and performance. The most common type of glove used for clinical procedures is natural rubber latex gloves which permit manual dexterity and are impermeable to microbes.

1. Gloves should be FDA approved.
2. Sterile surgical gloves should be used for all dental procedures performed by dentist or hygienist, other than patient examination and radiograph taking.
3. A glove should have a correct fit. Gloves that are too small, especially if worn for prolonged periods of time, will produce muscle fatigue in fingers and hands. If they are excessively tight over the wrists it can exacerbate the symptoms of carpal tunnel syndrome
4. Heavy duty, lined utility gloves should be used for general environmental cleaning and handling sharp items. These gloves are reusable, and should be washed while on the hands and dried. If excess sweating under the gloves becomes a problem, cotton glove liners can be worn. They need to be checked regularly for small tears, and discarded accordingly.
5. Double gloving is recommended in the following situations:
  - a. When the operator has dermatological condition.
  - b. With high risk patients to reduce risk of punctures.
  - c. When handling sharp objects such as crowns or wires.
6. Disposable clinical gloves should not be used for scrubbing instruments.

## Types of Gloves

Different glove types and their indications are listed in Table 11.

**Table 11**

### *Glove Types and Indications*

Glove	Indication	Comment	Material
Patient examination gloves	Patient examinations, Radiograph taking, and laboratory procedures. Double gloves should be used when cleaning or handling contaminated sharp items.	Medical device regulated by the Food and Drug Administration (FDA). Non-sterile and sterile single-use disposable. Use for one patient and discard appropriately.	<ul style="list-style-type: none"> <li>• Natural-rubber latex (NRL)</li> <li>• Nitrile</li> <li>• Nitrile and chloroprene (neoprene) blends</li> <li>• Nitrile and NRL blends</li> <li>• Butadiene methyl methacrylate</li> <li>• Polyvinyl chloride (PVC, vinyl)</li> <li>• Polyurethane</li> <li>• Styrene-based copolymer</li> <li>• Powder-less gloves</li> <li>• Flavored gloves</li> <li>• Low-protein gloves</li> </ul>
Surgeon gloves	Surgical procedures (all dental procedures performed by dentist or hygienist, other than patient examination and radiograph taking).	Medical device regulated by the FDA. Sterile and single-use disposable. Use for one patient and discard appropriately.	<ul style="list-style-type: none"> <li>• NRL</li> <li>• Nitrile</li> <li>• Chloroprene (neoprene)</li> <li>• NRL and nitrile or chloroprene blends</li> <li>• Synthetic polyisoprene</li> <li>• Styrene-based copolymer</li> <li>• Polyurethane</li> </ul>
Non-medical gloves	Cleaning and disinfection. Handling contaminated sharps or chemicals.	Commonly referred to as utility, industrial or general purpose gloves. Should be puncture or chemical-resistant, depending on the task. Latex gloves do not provide adequate chemical protection. Sanitize after use.	<ul style="list-style-type: none"> <li>• NRL and nitrile or chloroprene blends</li> <li>• Chloroprene (neoprene)</li> <li>• Nitrile</li> <li>• Butyl rubber</li> <li>• Fluoroelastomer</li> <li>• Polyethylene and ethylene vinyl alcohol copolymer</li> </ul>

Source: Modified from CDC [10]

## **Contact Dermatitis and Latex Hypersensitivity**

Occupationally related contact dermatitis can develop from frequent and repeated use of hand hygiene products, exposure to chemicals, and glove use. Contact dermatitis is classified as either irritant or allergic. Irritant contact dermatitis is common, non-allergic, and develops as dry, itchy, irritated areas on the skin around the area of contact. By comparison, allergic contact dermatitis (type IV hypersensitivity) can result from exposure to accelerators and other chemicals used in the manufacture of rubber gloves (e.g., natural rubber latex, nitrile, and neoprene), as well as from other chemicals found in the dental practice setting (e.g., methacrylates and glutaraldehyde).

Allergic contact dermatitis often manifests as a rash beginning hours after contact and, similar to irritant dermatitis, is usually confined to the area of contact. The use of hand lotions or creams may reduce dermatitis associated with frequent handwashing. DHCP should be educated regarding the signs, symptoms and diagnosis of skin reactions associated with frequent hand hygiene and glove use.

Latex allergy (type I hypersensitivity to latex proteins), on the other hand, can be a more serious systemic allergic reaction, usually beginning within minutes of contact with natural rubber latex, but sometimes occurring hours later, and producing varied symptoms. The symptoms of a latex allergy reaction may be skin reactions of urticaria (hives), redness, burning and itching. More severe reactions may involve respiratory symptoms such as runny nose, sneezing, watery itchy eyes, scratchy throat and asthma, marked by difficult breathing, coughing spells, and wheezing. Cardiovascular and gastrointestinal ailments may also develop, and in rare cases, anaphylaxis and death. Anaphylactic shock rarely occurs as the first sign of latex allergy but could occur with subsequent exposures.

Natural rubber latex proteins responsible for latex allergy are attached to latex glove powder. When powdered latex gloves are worn, more latex protein reaches the skin. In addition, when such gloves are donned or removed, latex protein/ powder particles become aerosolized and can be inhaled, contacting mucous membranes. HCP in work areas where

only powder-free, low-allergen latex gloves are used demonstrate fewer symptoms related to natural rubber latex allergy. Other dental items which can also put patients at risk of latex allergy include prophylaxis cups, rubber dams, orthodontic elastics, and medication vials.

Dental health care personnel and patients should be screened for latex allergy by taking medical history. Certain common predisposing conditions for latex allergy include:

1. A history of allergic disorders such as hay fever, allergic asthma, atopic dermatitis.
2. A history of allergic reactions to certain foods or grasses: avocado, banana, chestnut, kiwi, papaya, potato or ragweed.
3. A history of spina bifida, urogenital anomalies, or myelomeningocele/ meningocele.
4. A history of multiple surgical procedures, especially multiple genito-uretral surgeries in children.

Medical consultation should be requested when allergy is suspected. Furthermore, workers with any of the above predisposing factors should be periodically screened for latex allergy symptoms. Detecting symptoms early and removing symptomatic workers from latex exposure are essential to preventing long-term health effects.

To ensure a latex-safe environment for patients and DHCP with latex allergy, HCP with latex allergy, as well as those caring for patients with latex allergy, should be provided with reduced protein, powder-free gloves, or nonlatex gloves (e.g., nitrile or vinyl). Furthermore, DHCP and dental patients with latex allergy should not have direct contact with latex-containing materials, and all latex-containing products should be removed from their vicinity. Any latex-containing devices that cannot be removed from the treatment environment should be adequately covered or isolated. The following are further precautions which should be taken:

1. Patients with latex allergy can be scheduled for the first appointment of the day to minimize their inadvertent exposure to airborne latex particles.
2. Other DHCP should be informed (e.g., by oral instructions, writ-

ten protocols, and posted sign) regarding patients with latex allergy to prevent them from bringing latex containing materials into the treatment area.

3. All working areas contaminated with latex powder or dust should be cleaned frequently.
4. Emergency treatment kits with latex-free products should be available at all times.
5. If latex-related complications occur during or after a procedure, manage the reaction and seek emergency assistance as indicated.

### **Face Masks**

Face masks protect the face and oral and nasal mucous membranes during procedures likely to generate splashing or spattering of blood or other body fluids. Masks also prevent particles (respiratory droplets, skin squames) expelled into the environment by the wearer from contaminating the operatory field. Most masks produce a poor facial seal and are not designed to filter the air as it is breathed into the lungs. So they do not protect the wearer from aerosol inhalation.

#### ***Requirements of an Ideal Face Mask***

1. Does not come into contact with nostrils or lips.
2. Has a high bacterial filtration efficiency rate.
3. Fits snugly around the entire periphery of the mask.
4. Does not cause fogging of eyewear.
5. Easy to put on and remove.
6. Is made of fabric that does not irritate the skin or induce allergic reactions.
7. Made of fabric that does not collapse during wear or when wet.

#### ***Types of Face Masks***

1. Standard surgical facemasks.

- a. Provide no, or only partial, protection of the wearer from respiratory pathogens such as Mycobacteria tuberculosis or influenza.
  - b. May be dome shaped, or pliable.
  - c. May be secured with elastic bands, ear loops, or ties
  - d. Ties enhance stabilization during long procedures.
2. Respirator type masks.
- a. Provide high filtration of aerosols, and thus offer a higher degree of personal respiratory protection compared to a standard facemask.
  - b. Recommended for DHCP for use whilst treating patients with infections that are spread via aerosols e.g. tuberculosis and influenza.

### ***Indications for Wearing Face Masks***

1. It is essential for DHCP to wear mask when:
  - a. Coming in close proximity to patient's oral cavity.
  - b. Using handpiece, air/water syringe, or ultrasonic scaler.
  - c. Washing contaminated instruments.
  - d. Emptying a suction trap.
  - e. Disinfecting surfaces.
  - f. Taking radiographs.
  - g. Polishing with a lathe or a handpiece.
  - h. If DHCP is suffering from respiratory infection.
2. Masks should be worn properly and before gloving.
3. Masks should be changed between patients.
4. During patient treatment, masks should be changed at least once every hour, and more often if the mask becomes damp or wet, or if heavy spatter/ aerosol is generated during treatment.
5. Masks should not be touched or adjusted during procedures.
6. When removing masks, only the elastic bands or ties around the head or ears should be touched. The body of the used mask should not be touched with unprotected hands.



## Protective Eyewear, Face Shields

A variety of disease agents, such as the herpes simplex virus and hepatitis B virus, may cause harmful infections of the eye or may pass through ophthalmic mucous membranes and cause systemic infections. Protective eyewear may provide protection against infectious disease agents, splashes of chemicals during use of disinfectants and radiograph processing chemicals, as well as against physical damage to the eye by propelled objects, such as tooth fragments and restorative materials.

### **Types of Eye Protection Devices**

Table 12 compares different types of eye protection in relation to the American National Standards Institute: Occupational and educational eye and face protection, Z87.1-1989, New York, 1989. Due to the inadequate protection provided by glasses, they are unacceptable as eye protection devices for DHCP. Either goggles or face shields should be used for protection of the eye and face.

**Table 12**

*Comparison of Eye Protection Devices*

Type	Front Splash Protection	Side Splash Protection	Front Impact Protection	Side Impact Protection	Neck and Face Protection
Goggles	Excellent	Excellent	Excellent	Excellent	Poor
Glasses (no shields)	Good	Poor	Excellent	Poor	Poor
Glasses (w/ shields)	Good	Good	Excellent	Fair	Poor
Face shield	Excellent	Good to excellent	Variable (depends on thickness)	Variable (depends on thickness)	Variable (depends on type/length)

Source: Miller and Palenik [5]

### **Indications for Wearing Eye Protection Devices**

1. Whenever contamination of the eyes with aerosols, sprays or splashes of body fluids is possible.

2. Whenever projectiles may generated during any grinding, polishing or buffering procedure with rotary instruments or equipment.
3. Whenever handling chemicals, such as during disinfection procedures for patient care items or surfaces, or when handling radiography processing solutions.
4. When skin protection, is needed or desired, for example when irrigating a wound or suctioning copious secretions, a face shield should be used as a substitute to wearing a mask and goggles. The face shield should cover the forehead, extend below the chin, and wrap around the side of the face.
5. A face shield does not substitute for a surgical mask.
6. Reusable eye/ facial protective equipment should be cleaned with soap and water, or if visibly soiled, cleaned and disinfected between patients.
7. Contaminated protective eye wear or face shield should not be touched with unprotected hands.

### **Protective Clothing**

Protective clothing, i.e. gowns and head covers, should be worn to prevent contamination of street clothing and to protect the personal body parts of DHCP which are likely to be soiled with chemicals or blood, saliva or body substances during performance of the DHCP duties.

#### ***Requirements of Protective Clothing***

1. Should cover personal clothing and skin including the head, forearms, and chest area.
2. Veils worn by females outside the work area and ghutras worn by males are not appropriate protective clothing, and must be removed and replaced with appropriate well-fitting head covers.
3. Gowns and head covers may be reusable or disposable.
4. Disposable gowns and head covers must be discarded daily.

#### ***Indications for Wearing Protective Clothing***

1. Whenever a chance exists for contamination of skin or clothing

- with spray or splashes of saliva, blood or other potentially infectious materials.
2. Whenever a chance exists for contamination of skin or clothing with spray or splashes of chemicals.
  3. Female dental workers must wear a separate head cover for the working area and must change this head cover before leaving the clinic.
  4. DHCP should change protective clothing at the end of each clinical session, or when it becomes visibly soiled or is penetrated by body fluids.
  5. All protective clothing (gowns and head covers) should be removed before leaving the work area.

### **Placing and Removing Barriers**

Wearing or removing PPE should be done in a sequence that limits further spread of microorganisms. The combination of PPE used, and therefore the sequence, will be determined by the task to be performed, and hence the PPE which need to be worn.

### ***Sequence of Wearing PPE***

1. Gown and head cover first.
2. Mask.
  - The peripheries of the mask should be properly adjusted to fit.
  - The mask should not contact the nostrils or lips.
3. Goggles or face shield.
4. Gloves.
  - Hand hygiene should be performed immediately before donning gloves.
  - If an alcohol rub was used for antisepsis, hands must be completely dry before donning gloves because hands wet with alcohol-based product may increase risk of glove perforation.
  - Gloves should be extended over protective clothing cuffs

## ***Sequence of Removing PPE***

The sequence for removing PPE is intended to limit opportunities for self contamination. The gloves are considered the most contaminated pieces of PPE and are therefore removed first. The face shield or goggles are next because they are more cumbersome and would interfere with removal of other PPE.

Disposable PPE should be discarded appropriately upon removal, and not allowed to contact unprotected surfaces. Reusable PPE should be set aside in an appropriate place pending decontamination, in order to avoid contaminating unprotected surfaces.

1. Gloves.
  - The left glove should be grasped near the edge of the cuff and folded inside-out.
  - The right glove should then be removed completely.
  - The inverted inner aspect of the left glove may then be grasped with the ungloved right hand and the left glove removed completely
2. Face shield or goggles.
  - The ear or head pieces may be grasped with ungloved hands and lifted away from the face.
3. Gown.
  - If the gown is disposable, it may be removed with the gloves at the beginning in such a way that the gloves are peeled off from the hands with the gown as it is removed.
  - The gown is bundled with the contaminated surface folded inwards, and discarded appropriately.
4. Mask.
  - The mask should be removed by grasping the ties or elastic bands or loops. The front of the mask should not be touched with bare hands.
5. Head cover.
  - If the head cover is of the type that is pulled on and re-

moved over the head, care must be taken during removal that the outer surface of the cover does not contact the face.

## DESIGN OF CLINICS AND DENTAL UNITS

### Clinic Design

[2, 10, 85, 94]

Infection control considerations should be borne in mind during the designing of clinics within the College of Dentistry. The construction of the clinical areas should be conducive to prevention of cross-contamination, and the design of the clinic and dental units should utilize materials, surface textures, and shapes which permit easy and effective infection control procedures.

### ***Heating, Ventilation, and Air Conditioning Systems Health-care Facilities***

The clinic should be well ventilated. Air exchange in the operating area should be adequate to prevent pollution by aerosols generated during cavity preparation or by discharge from the evacuation (suction) system. Inefficient ventilation systems and/or contaminated air conditioning systems have been associated with increased levels of inhaled bacterial endotoxins by dental professionals. And chronic endotoxin inhalation is believed to represent an occupational respiratory hazard to dental professionals, for significant relationships between the level of endotoxin exposure and lung function decline have been reported in a number of studies.

Microorganisms proliferate in environments wherever air, dust, and water are present, and air-handling systems can be ideal environments for microbial growth. Therefore, ventilation system design and maintenance should adhere to the guidelines on Ventilation Specifications for Health-Care Facilities found in the American Institute of Architects' (AIA) Guidelines for Design and Construction of Hospitals and Health-Care Facilities (2010). Adequate records must be kept demonstrating that building ventilation conforms to the AIA requirements regarding the following:

1. Ventilation requirements for areas affecting patient care in hospitals and outpatient facilities.

2. Pressure relationships and ventilation of certain areas of nursing facilities.
3. Filter efficiencies for central ventilation and air conditioning systems in general hospitals.
4. Filter efficiencies for central ventilation and air conditioning systems in outpatient facilities.
5. Filter efficiencies for central ventilation and air conditioning systems in nursing facilities.

### ***Clinical Plan***

The design of the clinic should provide for adequate space to allow dental health care workers (DHCP) to maneuver in the clinic without inadvertently contacting contaminated surfaces.

The clinic should be divided into a “clean’ area where sterilized instruments and unused materials are placed and a “contaminated” area where used instruments and materials are placed. The sharps container and contaminated waste container should be placed in the contaminated area (see MANAGEMENT of MEDICAL WASTE). Furthermore, the treatment area should be used for treatment only. It should not be used for storage of items, plants, or cleaning materials other than those used within the clinic .

### ***Clinical Facilities***

Clinic surfaces (e.g. countertops, cabinets, walls, and floor) should be of non-absorbent highly polished material and of a finish which may be easily cleaned and disinfected. The clinic floor should not be carpeted. Flooring material should be of a non-absorbent material and should contain as few crevices and irregularities as possible. Clinic and equipment surfaces should generally be smooth with as few joints as possible.

The clinic should be designed with sufficient cabinet and drawer space to allow all devices and materials and, if necessary, instruments to be stored inside the drawers or cabinets and not left exposed to the clinic environment .

Hand hygiene facilities should have hands-free soap dispensers and

faucet controls so as to avoid their contamination by unwashed hands. Sensor-operated or foot controls may be utilized as well as elbow-controlled faucet handles. Sinks should be large enough and faucets placed in such a way to allow washing of hands without contacting the faucet or sink. Sinks should be constructed of a smooth, highly polished material, such as stainless steel or porcelain, which is amenable to repeated disinfection procedures. Furthermore, paper towel dispensers should be designed and positioned to allow paper towels to be pulled out individually without contamination of the dispenser or the remaining contents .

### **Dental Unit Design**

[6, 10, 95-99]

#### ***Dental Unit Waterlines and Hoses***

Microbial contamination of specific component parts of dental units is an important potential source of cross-infection. Of particular concern are the unit components that come into direct contact with the patient's oral cavity, including dental unit handpieces, three-in-one air/water syringes, and suction hoses. The dental unit output water is also of concern as a source of potential cross-infection as it enters the oral cavity.

Dental units should have anti-retraction valves (one-way flow check valves) to prevent aspiration of fluid and microorganisms from the oral cavity into the handpiece. Furthermore, dental instruments and equipment that are connected to the dental unit and which enter the patient's mouth (e.g., ultrasonic scalers, turbine and conventional handpieces, or air/water syringes) should contain integrated antiretraction valves or devices to prevent backflow of oral fluids into the dental unit water lines. This is important in light of the evidence that dental unit anti-retraction valves have been shown to fail in large numbers .

Whenever possible, dental units should have sterilizable handpiece hoses which may be removed and cleaned and disinfected and, if necessary, sterilized. If non-sterilizable hoses are used, they should preferably be strait, not coiled, and not covered, and of smooth outer surfaces which allow adequate cleaning and disinfecting. Straight tub-



ing is preferred over coiled because the size of the biofilm within coiled tubing is larger relative to the amount of water passing through, thus increasing the number of free-flowing bacteria exiting into the oral cavity during use. Furthermore, the coiled design may allow stagnation of more water inside the tubing during periods of rest, thus increasing the number of proliferating bacteria inside the tubing.

Dental unit waterlines (DUWLs) are an ideal environment for proliferation of microorganisms which enter them from the source water supply, and the oral cavity during use of the handpieces or air-water syringes. Therefore, the design of the dental units must facilitate treatment of the water passing through them and/or their waterlines in order to reduce the number of microorganisms exiting into the oral cavity to minimum levels. Acceptable designs include:

1. Autoclavable hoses or hoses which may be removed and mechanically cleaned and disinfected.
2. Self-contained dedicated water systems (a supply system in which the dental unit's water supply comes from a closed system such as a water bottle connected to the unit) which may be filled with water of known microbial and ionic quality, or which may allow the introduction of solutions for treatment of the water or waterlines.
3. Built-in reservoirs which communicate with the DUWLs and allow introduction of solutions for the treatment of the water exiting the waterlines.
4. Micro-filters placed near the exit of water lines to reduce the number of bacteria in the exiting water.
5. The preferred design which is units which may be used in combination with fully automated cleaning and disinfection systems that are validatable .

Self-contained delivery systems have the added benefit of enabling the dental unit to continue to function if it is desired to avoid the municipal water system . However, reservoir bottles can easily become contaminated with pathogenic skin micro-organisms, thus introducing additional potential pathogens into DUWLs. Therefore, reservoir

bottles should be cleaned and disinfected regularly, and handled using the aseptic technique. The reservoir bottles should be filled with fresh water each morning and residual water discarded each night, storing the empty bottle dry and inverted. Preferably, reservoir bottles that can be sterilized by autoclaving should be used .

If the dental unit is to be supplied with source water from the municipal supply, then the unit model must incorporate an air gap in the DUWLs to prevent the possibility of retraction of contaminated fluids into the main water supply .

If microbial filters are used, they must be changed regularly as they become clogged readily. Filters do not manage the biofilm, and should not be considered a substitute for biofilm treatments.

The temperature of the water in DUWLs has been shown to have an effect on the microbial counts of certain strains of bacteria. Therefore water heaters should not be used in dental units because warming the water may amplify biofilm formation and select organisms pre-adapted to growth in a human host. Water in the DUWLs should not be allowed to be warmer than 20-25 °C.

### ***Dental Unit Surfaces***

Dental unit components which regularly become contaminated with oral fluids during treatment (e.g. table, light switch, handles, saliva ejector, and high-volume evacuator (HVE) tubings and connectors, air-water syringes, and handpiece tubings) should, ideally, be detachable and sterilizable. If, however, they are non-detachable or are heat sensitive, they should be designed to allow easy and secure covering by an impervious barrier. Detachable, sterilizable air-water syringes are the ideal which must be pursued, if ever available. In their absence, syringes should be fitted to allow the use of disposable tips or have detachable, autoclavable tips.

To minimize contact of the operator's hand with unit surfaces during treatment, dental units should have sensor or foot controls for most of the necessary functions required of the unit. If hand controls are utilized, they should be designed such that they are amenable to being

covered by a barrier easily and securely.

All unit surfaces, as well as the operator and assistant's stools, should be constructed of a material, which can withstand repeated cleaning and disinfection with an appropriate disinfectant. The upholstery should also be constructed of durable, non-organic materials, be impervious to moisture, and seamless to reduce microbial entrapment and increase disinfection efficiency.

X-ray viewers attached to dental unit tables have the potential for higher rates of contamination compared to viewers placed away from the unit. Such viewers, therefore, are more likely to cause contamination of radiographs placed on them. Hence, it is preferable to avoid viewers attached to dental unit tables.

## DENTAL TREATMENT WATER

### Clinical Water Supply

[10, 94-97, 100-101]

Microbial contamination of DUWLs originates principally from the dental unit water supply, which usually contains low levels of micro-organisms. These micro-organisms form microcolonies within DUWLs that eventually give rise to multispecies biofilms. The poorer the quality of water supplied to DUWLs, the more readily biofilm is likely to form on its internal surfaces.

The quality of dental unit output water is directly influenced by the quality of the incoming supply water. Such quality is determined by the physical content (i.e. presence of suspended material and particulate matter), chemical content (i.e. organic material and dissolved and suspended inorganic compounds) and microbiological quality (i.e. density of micro-organisms present) of the water. The condition of the water distribution network pipes, and storage tanks, as well as water temperature, also have a considerable role in water quality.

The microbial counts within the source water must be regularly monitored, and the non-pathogenic bacterial count should not exceed 500 cfu/ml, (which is the regulatory standard for safe drinking water established by the Environmental Protection Agency, American Public Health Association, and American Water Works Association).

In the event that the municipal water supply has been judged to be unfit for drinking, it should not be used as a source for dental treatment water. A separate water reservoir should be used instead, or water of known quality in a self-contained system. During these periods, tap water should not be used to dilute germicides or for hand hygiene. For hand hygiene, antimicrobial products that do not require water (e.g., alcohol-based hand rubs) can be used. If hands are visibly contaminated, bottled water and soap should be used for hand-washing. If bottled water is not immediately available, an antiseptic wipe should be used.

After the municipal water has become safe for drinking, all incoming waterlines from the public water system (e.g., faucets, waterlines, and

dental equipment) should be flushed for 5 minutes. After the incoming public water system lines are flushed, dental unit waterlines should be disinfected.

Water softening applied to the dental unit supply water is vital in hard water areas because mineral deposits inside DUWLs allow more biofilm to form and may eventually result in clogging of DUWLs. If the incoming water supply has a mineral hardness  $\geq 200$  ppm, water softening units which produce water suitable for the dental chairs should be used to treat the water before it enters the dental units. The water softening unit should have an integrated backwash facility timed to operate when the softening unit is not being used. Water softening units should receive periodic maintenance, regeneration and disinfection. Proper maintenance is essential because biofilm can develop within the water softening unit's resin bed after a period of use, thus considerably increasing the microbial loads in water entering the dental units water downstream of the softening units.

Proper installation of water softening units is also important as their location and set-up has often been found to be suboptimal, particularly if used in combination with other types of filtration devices such as carbon filters, used to remove organic matter from water.

Sediment filters should be fitted in-line with the incoming dental unit water supply **before** any other pretreatment system or device. Such filters should be equipped with an integrated backwash function that allows them to restore their full filtration capacity at times when there is no demand on the water supply network. These sediment filters prolong the life of other water treatment systems which the water will pass through by eliminating gross contaminants that would otherwise clog either the resin beds of water softening units or activated carbon filters by reducing the surface area available for absorption.

Activated **carbon filters** remove or reduce many volatile organic chemicals, pesticides and herbicides, as well as chlorine, endotoxins and solvents found in incoming water. They should be adequately sized to cope with high contamination episodes.

Kinetic degradation fluxion (KDF) filters should be used for removal

of dissolved metals from the incoming water supply. Such filters contain a high-purity copper–zinc matrix that uses the principle of oxidation /reduction (redox) to remove chlorine, lead, mercury, iron and hydrogen sulfide from water supplies. When placed inline before carbon filters, KDF filters can greatly extend the life and efficiency of the carbon filters.

The order of treatment of the incoming water supply should be as follows:

1. Sediment filter.
2. Water softening.
3. KDF and carbon filters.
4. DUWLs solutions for removal of the biofilm.

Periodic maintenance of pretreatment facilities must be carried out. If independent reservoirs are used, equipment used to produce distilled or deionized water for use in independent reservoirs should be regularly maintained to ensure good quality output water. It must also be ensured that the storage conditions within the reservoirs does not result in deterioration of water quality.

### **Treatment of Dental Unit Waterlines**

[5, 10, 94-100, 102-109]

The occurrence of high densities of microorganisms (up to 10<sup>6</sup> cfu/mL) and bacterial endotoxins (500-10<sup>5</sup> endotoxin units (EU) per ml) in dental unit output water has been reported in various literature, and constitutes a potential risk of infection for dental patients and dental healthcare and support staff. The onset of asthma in dentists may be associated with occupational exposure to aerobic bacterial concentrations in DUWLs  $\geq$  200 cfu/ml, and a multitude of respiratory symptoms may be caused by inhalation of airborne bacterial endotoxins. In the absence of an adequate infection control regimen, the number of microorganisms has been found to increase to unacceptable levels. Bacterial endotoxins have also been found in the air of dental operatories in amounts ranging from 2.7-625 EU/m<sup>3</sup> of air, and DUWLs have been identified as an important source of such endotoxins.

The biofilm matrix within DUWLs also contains both inorganic and organic material derived from supply water and dead microorganisms. Such microbial content enters the oral cavity of the patient during treatment, and the aerosols and droplets produced by dental instruments connected to DUWLs may be inhaled by patients and dental health-care personnel, leading to a variety of adverse medical problems and consequences.

Therefore, the microbial count in dental unit output water must be reduced to levels suitable for the procedure being performed. The source of the water used for dental treatment may be tap water, distilled water, or sterile water, according to the procedure performed and the instructions of the delivery device's manufacturer. Whatever the quality of the source water or type of delivery system used in dental units, the biofilm within the DUWLs must be removed by a proven method. The most efficient means of achieving good quality DUWL output water is regular treatment/disinfection of DUWLs with a chemical, biocide or cleaning agent that removes biofilm from DUWLs effectively, resulting in good quality output water.

The fluid used for irrigation of surgical wounds and during surgical procedures should be sterile water or saline solution. Furthermore, the maximum acceptable level of endotoxins in sterile water used for irrigation is 0.25 EU /mL , and for airborne endotoxins is 50 EU/m<sup>3</sup> (based on personal inhalable dust exposure measured as eight hour time weighted average. When sterile irrigating solutions are used, the date of opening of the water bottle must be noted on the bottle. The bottle should no longer be considered sterile at the end of the day, or sooner if contamination is suspected.

For non-surgical procedures, regardless of the source water, the number of bacterial counts of non-pathogenic bacteria in the water exiting the device into the oral cavity be as low as reasonably achievable without exceeding 500 cfu/ml.

The following approaches are acceptable methods for reduction of the number of microorganisms and bacterial endotoxins exiting the waterlines:

1. Use of single-use disposable or sterilizable tubing,
2. Elimination of the biofilm,
3. Treatment of the waterlines chemically to reduce the viability of the microorganisms in the biofilm, or
4. Use of microfiltration devices placed inside DUWLs to treat water exiting the waterlines.

### ***Single-use Disposable or Sterilizable Tubing***

Whenever possible, single-use disposable or sterilizable tubes which allow the cleaning and removal of the organic matrix of the biofilm from their lumens, are the preferred method of controlling the microbial population within DUWLs. When used with a self-contained, sterile water source, this type of system may even be used during surgical procedures.

### ***Elimination of the Biofilm***

When using non-detachable tubings, management of waterline contamination should aim at elimination of the biofilm. Attempting to eliminate the resident bacteria without removal of the biofilm is an inadequate approach to DUWL treatment which may increase the hazards of contaminated water. Biofilm re-growth in DUWLs usually occurs within a week following disinfection/cleaning and so DUWLs need be treated regularly

Elimination of the biofilm may be achieved through the use of a variety of chemical products. Any product used must be:

1. Shown to be effective in the independent literature,
2. Compatible with the DUWL components (as recommended by the dental unit manufacturer),
3. Non-toxic to patients or DHCP when used as recommended by the dental unit manufacturer , and
4. Does not have adverse effects on the environment.

Research has shown that a range of disinfectants and cleaning agents used to treat DUWLs may cause the release of mercury from dental amalgam when tested in the laboratory. Thus, it is of concern



that such agents could also mobilize mercury from dental amalgam collected in amalgam filters, traps and separators and in dental unit waste water lines and pipes and release it into the environment. Chlorine containing products were shown to cause the release of more mercury than other products.

Introduction of the chemical agent into the waterlines may be either intermittent or continuous. The intermittent method involves placement of the chemical agent in a self-contained water reservoir (the source bottle) and flushing the water lines to allow the chemical to fill all the tubings. The chemical is, then, left in contact with the tubings for the appropriate contact time advised by the chemical's manufacturer. Afterwards, the chemical should be flushed out thoroughly with water, and, depending on the type of chemical disinfectant, the unit is not put into use for a specified number of hours. If the unit is connected to the municipal water mains supply, it is imperative that the connection is turned off prior to treatment of the waterlines to prevent contamination of mains water with treatment agent.

The advantage of the intermittent method of treatment is that the chemical is removed from the waterlines before patient treatment. Disadvantages are that it is time consuming and must be performed weekly to prevent surviving biofilm organisms from reforming the biofilm. Furthermore, the exposure of DHCP to chemicals is a disadvantage with any treatment modality which utilizes chemical agents. However, if dental units with fully automated cleaning and disinfection systems are used, the time and effort, as well as exposure to chemicals, required for intermittent cleaning are reduced.

The continuous method of waterline treatment involves mixing low concentrations of the chemical agent with the dental treatment water. This may be achieved either through mixing the chemical agent with the source water in a self-contained system or through placement of the agent in a reservoir inside the dental unit which provides for measured, continuous release into the water passing through the tubings. The continuous method may be used alone or may be used after a single regimen of the intermittent type. Advantages of the continuous type are the reduced potential for recolonization of the waterlines and ease

of application. However, the continuous presence of the chemical and its subsequent aerosolization during patient treatment leads to chronic exposure of DHCP. Dental adhesive materials, also, may be affected by the presence of such chemicals in the dental treatment water.

Once a dental unit is in place, the dental unit manufacturer's instructions must be observed regarding the protocol and choice of chemical for treatment of the DUWLs, while ensuring the method and chemicals used have been proven to be effective. Adherence to maintenance protocols is necessary as non-compliance has been associated with persistence of contamination of the water.

### ***Elimination of Viable Bacteria***

Attempting to eliminate bacteria without removal of the biofilm will only lead to quick re-colonization of the matrix with bacteria. Microorganisms within the biofilm are more resistant to antimicrobial agents than free-floating microbes. The chronic, continuous treatment of the water with chemical disinfectants without removal of the biofilm may lead to further microbial resistance, and may increase the hazards of contaminated water and should, therefore, not be attempted. Therefore, only DUWL cleaners that have been demonstrated to eliminate both viable and biofilm bacteria should be used.

### ***Microfiltration***

Microfilters placed near the exit of waterlines may reduce the number of bacteria in dental treatment water. Sediment filters commonly found in dental unit water regulators have pore sizes of 20-90  $\mu\text{m}$  and do not function as microbiological filters. Microfiltration commonly occurs at a filter pore size of 0.03-10  $\mu\text{m}$ .

Filters are usually installed on dental unit waterlines as retrofit devices. The nearer the filters are placed to the exit of the tubings, the lower the bacterial counts achieved. Filters have been shown to completely eliminate or reduce the microbial counts in water exiting DUWLs to  $< 200$  cfu/ml.

Although filters prevent free-floating bacteria within the water lines from exiting into the treatment area, the biofilm and bacteria are not

eliminated from within the lines. Thus, bacterial endotoxins in the dental treatment water are not reduced. However, filters have been developed which are able to remove endotoxins.

Disadvantages of filters are the persistence of the biofilm in the tubings with the resultant risk of biofouling and clogging. Therefore, filters are not sufficient to manage the water-line problem alone, but they may be used in conjunction with other water-line treatment methods to improve the quality of outgoing water.

### ***Combined Approach***

An ideal water-line treatment regimen would be filters combined with an intermittent treatment of the water-lines to remove the biofilm. This regimen combines the benefits of a) biofilm removal without chronic exposure of DHCP and patients to chemicals, and b) delivery of chemical-free, bacteria-free water in between treatment episodes.

Furthermore, flushing for 2 minutes in the morning and for 20–30 seconds after each patient should be considered the norm for dental surgery procedures, and longer flushing is suggested after weekends. Flushing at the beginning of the day should be performed without hand-pieces connected to the waterlines. However, flushing alone, without concomitant treatment of the biofilm, is not an acceptable method to reduce the microbial load in dental unit output water since it has been reported to lead to a higher microbial load due to dislodging of pieces of the biofilm during treatment.

At the end of each working day, the water supply should be disconnected and the water lines purged with air.

If the dental units have antiretraction devices, the manufacturer must be consulted to determine whether testing or maintenance of antiretraction valves or other devices is required. If required, efficacy testing of antiretraction valves/devices should be performed yearly.

## CHEMICALS USED FOR DISINFECTION AND STERILIZATION IN DENTISTRY

The choice of methods for cleaning, disinfection and sterilization of patient-care medical devices and for cleaning and disinfecting the healthcare environment should be based upon evidence-based recommendations. Furthermore, for maximum effectiveness when using chemicals for such processes, health-care workers should adhere strictly to the cleaning, disinfection, and sterilization recommendations in this document and to instructions on product labels. [82]

### Definition of Terms

[2, 10, 82]

- Sterilization: a process that destroys or eliminates all forms of microbial life. When chemicals are used to destroy all forms of microbiologic life, they can be called chemical sterilants. These same chemicals used for shorter exposure periods also can lead to disinfection.
- Disinfection: a process that eliminates many or all pathogenic microorganisms, except bacterial spores, on inanimate objects.
- Decontamination: removal of pathogenic microorganisms on a surface or item so that they are no longer capable of transmitting infectious particles and the surface or item is rendered safe for handling, use, or disposal.
  - The decontamination procedure depends on the item or surface being processed. For example, sterilization is the appropriate decontamination procedure for surgical instruments, whereas disinfection is sufficient for clinic surfaces.
- Sanitation: reduction of the numbers of bacterial contaminants to safe levels as judged by public health requirements.
- Cleaning: the removal of visible soil (e.g., organic and inorganic material) from objects and surfaces.

- Disinfectants: antimicrobials applied only to inanimate objects. Disinfectants are not used for skin antisepsis because they can injure skin and other tissues.
- Antiseptics: antimicrobial chemicals applied to living tissue and skin. Antiseptics are used only on the skin and not for surface disinfection.
- Germicide: an agent that can kill microorganisms, particularly pathogenic organisms (“germs”). The term germicide includes both antiseptics and disinfectants.
  - Terms with the suffix -cide or -cidal (e.g. virucide, fungicide, bactericide, sporicide, and tuberculocide) indicate the ability to kill the type of microorganism identified by the prefix. For example, a bactericide is an agent that kills bacteria.

### Classification of Items and Surfaces for Decontamination

[2, 10]

#### ***Patient Care Items***

According to their uses and potential risk for transmission of infection, instruments, devices, and equipment used in healthcare settings are classified as critical, semi-critical, or non-critical.

- a. Critical instruments are surgical instruments and those instruments that penetrate soft tissue or bone (e.g. forceps, scalpels, bone chisels, scalers, burs).
  - Critical instruments confer a high risk for infection if they are contaminated with any microorganism, and should, thus, be sterilized after each use.
- b. Semi-critical instruments are those that do not penetrate soft tissues or bone but contact oral tissues (e.g. mirrors and amalgam condensers) or non-intact skin.
  - Semi-critical instruments, also, should be sterilized after each use.

- Heat-sensitive semi-critical items should be sterilized with chemical sterilants, or, at minimum, undergo high-level disinfection.
- c. Non-critical instruments are those that contact only intact skin (e.g. external components of x-ray tubes).
  - Such items may be disinfected between patients with a low-level disinfectant (see below).
  - If, however, the surface of the item is visibly soiled with patient material, then it must be disinfected with an intermediate-level disinfectant (i.e. one with a tuberculocidal claim) (see following section). Pre-cleaning with a detergent before disinfection may be necessary depending on the type of disinfectant used.

### ***Environmental Surfaces***

In the clinic, environmental surfaces are surfaces or equipment that do not contact patients directly but may become contaminated with patient material indirectly via contaminated hands or patient care items. Based on the potential risk of contamination, the various environmental surfaces can be divided into clinical contact surfaces and housekeeping surfaces (see section Environmental Surfaces). These two types of surfaces require different types of cleaning/disinfecting agents and protocols.

- a. Clinical contact surfaces are those surfaces which risk being contaminated with aerosols and spatter or touched with contaminated gloves during operation. Such surfaces, if contacted with contaminated gloves, can be potential reservoirs of microbial contamination.
- b. Housekeeping surfaces are those surfaces which are less likely to be contacted with contaminated gloves but may become contaminated with aerosols, spatter, or spills. Examples of such surfaces are floors, walls, and hand washing sinks.

## Classification of Antimicrobials

[10, 82]

In the United States, the Environmental Protection Agency (EPA) is a governmental agency that regulates disinfectants that are used on environmental surfaces (housekeeping and clinical contact surfaces), and not those used on critical or semi-critical medical devices. The Food and Drug Administration (FDA) is the governmental body which regulates liquid chemical sterilants/ high-level disinfectants (e.g., glutaraldehyde, and hydrogen peroxide) used on critical and semi-critical patient-care devices. Antiseptics are considered antimicrobial drugs used on living tissue and thus are regulated by FDA.

The EPA and FDA classify disinfectants differently. The EPA registers environmental surface disinfectants based on the manufacturer's microbiological activity claims when registering its disinfectant. To be labeled as an EPA "hospital disinfectant", the product must have demonstrated effectiveness against the following micro-organisms:

1. *Salmonella choleraesuis* (for effectiveness against gram-negative bacteria);
2. *Staphylococcus aureus* (for effectiveness against gram-positive bacteria); and
3. *Pseudomonas aeruginosa* for effectiveness against a primarily nosocomial pathogen.

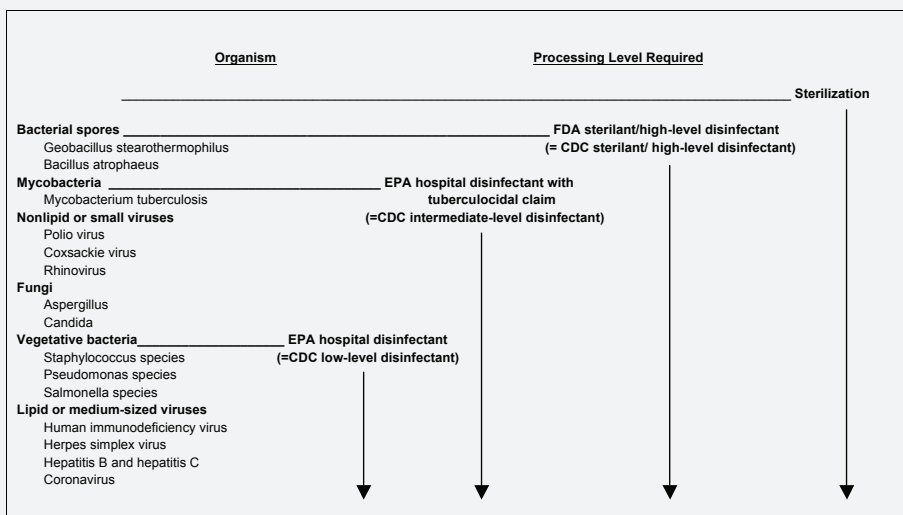
The EPA also lists disinfectant products according to their labeled use against organisms of interest (*Mycobacterium tuberculosis*, HIV, HBV, HCV). Because *Mycobacterium tuberculosis* has among the highest levels of resistance among the vegetative bacteria, viruses, and fungi, if a product is labeled as "tuberculocidal", it is considered capable of inactivating a broad spectrum of pathogens, including HBV, HCV, and HIV. Although *Mycobacterium tuberculosis* is transmitted by the airborne route, and not via environmental surfaces, disinfectants are tested for their activity against it to determine if they have broad-spectrum capability. Updated lists of EPA registered products are available at the EPA website at <http://www.epa.gov/oppad001/chemregindex.htm>.

The FDA, on the other hand, defines antimicrobial potency as sterilization, and high-, intermediate- and low-level disinfection. This difference has led to confusion on the part of users because the EPA does not use such terms. The Center for Disease Control (CDC) of the U.S. National Institute of Health designates any EPA-registered hospital disinfectant without a tuberculocidal claim as a low-level disinfectant and any EPA-registered hospital disinfectant with a tuberculocidal claim as an intermediate-level disinfectant. Furthermore, the FDA defines a high-level disinfectant as a sterilant used under the same contact conditions as sterilization except for a shorter immersion time.

Figure 2 demonstrates the relationship of the two classifications with each other and with antimicrobial activity.

**Figure 2**

*Decreasing Order of Resistance of Microorganisms to Germicidal Chemicals*



Source: CDC [10]

**Uses of Antimicrobials [2, 5-6, 10, 82]**

Antimicrobial formulations used in the College must be EPA registered or cleared by the FDA, or they must have had their efficacy proven under conditions of use, as demonstrated by independent stud-



ies in peer-reviewed journals.

In most instances, a given product is designed for a specific purpose and is to be used in a certain manner. Therefore, users should read labels carefully to ensure the correct product is selected for the intended use and applied efficiently. Use of a product for purposes for which it is not labeled is contraindicated. Furthermore, the component materials of patient care items and environmental surfaces may be incompatible with certain disinfectants. Therefore the choice of disinfectants used must take into account the instructions of the manufacturers of the items and surfaces to be decontaminated.

Disinfectants have varying tissue toxicity, but personal protective equipment (gloves, eye protection, mask, and protective clothing) should be worn when using any disinfectant.

Depending on the item or surface to be disinfected, and the nature of the contaminant, different levels of disinfection are required.

### ***Patient Care Items***

The use of high-level disinfectants/sterilants to sterilize patient-care items is highly discouraged and should only be used if all the following criteria are met:

- a. The item is not a critical patient-care item (i.e. not intended to penetrate tissues),
- b. Item is not heat-tolerant,
- c. There are no autoclavable options to replace the item, and in the absence of other safer sterilization techniques.

Three levels of disinfection: high, intermediate, and low, are used for patient-care devices that are not critical patient-care items. The intended use of the patient-care item should determine the recommended level of disinfection (see section above, on Classification of Patient Care Items).

Before any germicide formulation is used to decontaminate a dental device, the device manufacturer 's instructions must be referred to check for compatibility with the germicide.

## ***Environmental Surfaces***

Depending on the surface and the nature of the contaminant, environmental surfaces may be decontaminated by either intermediate- or low-level disinfection.

For de-contamination of clinical contact surfaces, either an EPA-registered hospital tuberculocidal disinfectant (intermediate-level disinfectant) or an EPA registered hospital disinfectant (low-level disinfectant) labeled as effective against HIV and HBV is appropriate. Hospital disinfectants with such HIV and HBV claims can be used, provided surfaces are not contaminated with microorganisms for which higher level (i.e., intermediate-level) disinfection is recommended (see Figure 2 for examples).

Housekeeping surfaces need to be cleaned only with a detergent and water or an EPA-registered hospital disinfectant/detergent (low-level disinfectant). If visibly soiled with patient material, in cases of spills, either an EPA-registered hospital tuberculocidal disinfectant (intermediate-level disinfectant) or an EPA registered hospital disinfectant (low-level disinfectant) labeled as effective against HIV and HBV may be used.

The following table (Table 13) is a summary of the categories of disinfectants/sterilants and their recommended uses in dentistry.

**Table 13**

*Categories of Disinfectants/ Sterilants and Recommended Uses in Dentistry*

Category	Definition	Examples	Uses
Sterilant	Destroys all microorganisms- including high numbers of bacterial spores	Glutaraldehydes Hydrogen peroxide (Depending on the contact time)	Semi-critical heat sensitive items. Immersion only
High-level disinfectant	Destroys all microorganisms- but not necessarily high numbers of bacterial spores	Glutaraldehydes Hydrogen peroxide (Depending on the contact time)	Semi-critical heat sensitive items. Immersion only
Intermediate-level disinfectant	Inactivates Mycobacterium tuberculosis (tuberculocidal)- and destroys vegetative bacteria, most fungi and most viruses	Chlorine and chlorine compounds Iodophors Phenolics Quaternary ammonium compounds with alcohol	Clinical contact surfaces Non-critical items visibly soiled with patient material Spills of patient material
Low-level disinfectant	Does not inactivate Mycobacterium tuberculosis (is not tuberculocidal)- but destroys vegetative bacteria, some fungi, and some viruses	Quaternary ammonium compounds	Clinical contact surfaces (if active against HBV, HIV) Spills of patient material (if active against HBV, HIV) Housekeeping surfaces (e.g. floors and walls) Non-critical items without visible patient material

*Source: Adapted from Schulster, et al. [2], CDC [10], CDC [82]*

## Factors Affecting the Efficacy of Chemical Disinfection and Sterilization [10, 82]

The activity of germicides against microorganisms depends on a number of factors, some of which are intrinsic qualities of the organism, others of which are the chemical and external physical environment. Awareness of these factors should lead to better use of disinfection and sterilization processes. Factors that affect the efficacy of both disinfection and sterilization include prior cleaning of the object; organic and inorganic load present; type and level of microbial contamination; concentration of and exposure time to the germicide; physical nature of the object (e.g., crevices, hinges, and lumens); and presence of biofilms.

### ***Number and Location of Micro-organisms***

The larger the number of microbes, the more time a germicide needs to destroy all of them. Reducing the number of microorganisms that must be inactivated through meticulous cleaning shortens the exposure time required to kill the entire microbial load.

This reinforces the need for scrupulous cleaning of medical instruments before disinfection and sterilization.

### ***Organic and Inorganic Matter***

Organic matter in the form of serum, blood, pus, or lubricant material can interfere with the antimicrobial activity of disinfectants by:

1. Reacting with the germicide (resulting in a complex that is less germicidal and leaving less of the active germicide available for attacking microorganisms). Chlorine and iodine disinfectants are prone to such interaction.
2. Protect microorganisms from attack by acting as a physical barrier.

Inorganic contaminants may also protect microorganisms from the action of disinfectants. This further emphasizes the importance of meticulous cleaning of medical devices before any sterilization or disinfection procedure because both organic and inorganic soils are easily

removed by washing.

### ***Pre-cleaning of Surfaces***

Cleaning is the necessary first step of any disinfection process. The physical action of scrubbing with detergents and rinsing with water removes substantial numbers of microorganisms. Cleaning also removes organic matter, salts, and visible soils, all of which interfere with microbial inactivation. If a surface is not cleaned first, the success of the disinfection process can be compromised. Removal of all visible blood and inorganic and organic matter can be as critical as the germicidal activity of the disinfecting agent. Some antimicrobial formulations incorporate cleaners with the antimicrobial agent such that the cleaning and disinfection is performed simultaneously, and no pre-cleaning is required.

### ***Concentration and Potency of Disinfectants***

With one exception (iodophors), the more concentrated the disinfectant, the greater its efficacy and the shorter the time necessary to achieve microbial kill. Not all disinfectants, however, are similarly affected by concentration adjustments.

### ***Contact Times for Surface Disinfectants***

Items must be exposed to the germicide for the appropriate minimum contact time (duration of exposure). All applicable label instructions regarding contact time must be followed.

An important issue concerning use of disinfectants for non-critical items and environmental surfaces in health-care settings is that the contact time specified on the label of the product is often too long to be practically followed. Product users should consider and use products that have the shortened contact time. A contact time of 10 minutes (as specified by many products registered use against HBV, HIV, or M. tuberculosis) for such surfaces is not practical because the disinfectants are usually applied and allow it to dry (~1 minute). Currently, some EPA-registered disinfectants have contact times of one to three minutes.

With FDA-cleared liquid chemical sterilants, contact time is the single critical variable distinguishing sterilization from high-level disinfection.

### ***Physical Nature of the Object***

Crevices, joints, and channels are more difficult to disinfect than are flat-surface equipment because penetration of the disinfectant of all parts of the equipment is more difficult. Only surfaces that directly contact the germicide will be disinfected.

### ***Presence of Biofilms***

See section “Treatment of Dental Unit Waterlines.”

## **Properties of Ideal Disinfectant [6]**

The following are the properties of an ideal disinfectant:

- Broad Spectrum (tuberculocidal)
- Fast-acting
- Active in the presence of organic matter such as blood, sputum, and pus
- Nontoxic
- Non-allergenic
- Surface compatibility
- Residual effect on treated surfaces
- Easy to use
- Odorless
- Economical

## **Chemical Disinfectants and Sterilants**

Many disinfectants are used alone or in combinations (e.g., hydrogen peroxide and peracetic acid) in the health-care setting. Disinfectants marketed for use in dental settings include alcohols, chlorine and chlorine compounds, glutaraldehyde, hydrogen peroxide, iodophors, phenolics, and quaternary ammonium compounds. Commercial formulations based on these chemicals are considered unique products

and only those products registered with the EPA or cleared by the FDA should be used. [82]

### ***Alcohols [2, 5-6, 82]***

In the healthcare setting, “alcohol” refers to two water-soluble chemical compounds—ethyl alcohol and isopropyl alcohol. Alcohols are tuberculocidal agents, but they are not sporicidal.

Alcohol evaporates rapidly, and although some products have extenders added which may retard evaporation, extended contact times are difficult to achieve unless the items to be disinfected are immersed in the alcohol solution.

Furthermore, alcohols are poor cleaners because of their inability to penetrate or dissolve protein-rich materials. Such compounds, in fact, denature and dehydrate proteins, making the proteins insoluble and strongly adherent to most surfaces. In addition, the formation of a coating of denatured protein may protect microorganisms from the microbial action of the alcohol.

Because of their reduced activity in the presence of organic material such as blood and saliva, poor cleaning property, and rapid rate of evaporation, alcohols should not be used as large- area surface disinfectants. And because of their lack of sporicidal action and inability to penetrate proteinaceous materials, they should not be used to sterilize patient care items.

In dentistry these compounds are mainly used as antiseptics. Although alcohols may cause skin dryness, some products have skin moisturizers added to reduce this effect. When used as skin antiseptics, the formulations should have added antimicrobial ingredients to achieve persistent activity on skin.

#### ***Advantages.***

- Tuberculocidal (at 70% concentration).
- Fast-acting.
- Only slightly irritating to skin.
- Economical.

### ***Disadvantages.***

- Lack sporicidal action.
- Cannot penetrate or dissolve protein-rich materials, therefore are poor cleaners.
- Reduction in activity by organic material.
- Evaporate rapidly.
- Swell and harden rubber and certain plastic tubing after prolonged and repeated use.
- Corrosive to metals.
- Cause skin dryness.
- Flammable; must be stored in a cool, well-ventilated area.

### ***Uses.***

- Mainly as skin antiseptics.
- Not recommended for sterilizing patient care items.
- Not recommended as single agents for environmental disinfection.

### ***Chlorine and Chlorine Compounds [6, 10, 82]***

Hypochlorites, the most widely used of the chlorine disinfectants, are EPA registered intermediate-level surface disinfectants, and are available as liquid (e.g., sodium hypochlorite) or solid (e.g., calcium hypochlorite). Under certain conditions, these agents may be sporicidal.

The most prevalent chlorine products are aqueous solutions of 5.25%–6.15% sodium hypochlorite, usually called household bleach. A 1:1,000 dilution of household bleach provides about 53–62 ppm available chlorine, and a 1:10 dilution of household bleach provides about 5250–6150 ppm. Chlorine-based products that are EPA-registered as intermediate-level disinfectants are available commercially. However, in the absence of an EPA-registered chlorine-based product, a fresh solution of sodium hypochlorite (e.g., household bleach) is an inexpensive and effective intermediate level germicide. Concentrations ranging from 500 ppm to 800 ppm of chlorine (1:100 dilution of 5.25% bleach



and tap water) are effective on environmental surfaces that have been cleaned of visible contamination.

“Superoxidized water” is electrolyzed saline which produces hypochlorous acid (e.g., at a concentration of about 144 mg/L) and chlorine. Such a disinfecting solution is nontoxic to biologic tissues. Superoxidized water is FDA cleared as a high-level disinfectant.

Caution should be exercised, however, because chlorine solutions are incompatible with some clinical surfaces and are corrosive to metals, especially aluminum. Therefore, as with all disinfectants, the manufacturer’s instructions must be referred to determine compatibility. And as with all chemicals, appropriate personal protective equipment should be worn when preparing hypochlorite solutions.

### ***Advantages.***

- EPA registered intermediate-level surface disinfectant.
- Broad spectrum of antimicrobial activity.
- Fast acting.
- Effective in dilute solution.
- Do not leave toxic residues.
- Unaffected by water hardness.
- Inexpensive.
- Remove dried or fixed organisms and biofilms from surfaces.
- Low incidence of serious toxicity.

### ***Disadvantages.***

- Chemically unstable solution (necessary to produce diluted solutions fresh daily).
- Diminished activity by organic matter (longer contact time required in presence of organic matter).
- Irritating to skin and mucosa.
- Unpleasant persistent odor at high concentrations.
- Corrosiveness to metals in high concentrations (>500 ppm).
- Discoloring or “bleaching” of fabrics.

- Degrading to plastics and rubber.
- Release of toxic chlorine gas when mixed with ammonia or acid (e.g., household cleaning agents).

### **Uses.**

- Disinfection of surfaces and floors.
  - Blood spills may be decontaminated with 1:10–1:100 dilution of household bleach, after cleaning with a detergent.
  - For small spills of blood (i.e., drops of blood) on noncritical surfaces, the area can be disinfected with a 1:100 dilution of household bleach.
- Disinfectant in water treatment.
- Irrigating agent in endodontic treatment.
- Disinfectant for laundry.
- Disinfectant for dental appliances (if compatible with surfaces).
- Disinfectant for regulated medical waste before disposal.

### ***Glutaraldehyde [2, 5-6, 10, 82]***

Glutaraldehyde is a high-level disinfectant and chemical sterilant. If used to sterilize patient-care items, only FDA approved products classified as sterilants/high-level disinfectants should be used.

Sterilization with glutaraldehyde is reliably only if cleaning precedes treatment (because bioburden on the items interferes with the sterilization process) and if the manufacturer instructions are followed regarding concentration, contact time, temperature, and pH.

Aqueous solutions of glutaraldehyde are acidic and generally in this state are not sporicidal. Only when the solution is “activated” (made alkaline) by use of alkalinating agents to pH 7.5–8.5 does the solution become sporicidal. Once activated, these solutions have a shelf-life of minimally 14 days. Some formulations have overcome the problem of rapid loss of activity (e.g., use-life 28–30 days) while generally maintaining excellent microbicidal activity. Antimicrobial activity of glutaraldehydes depends not only on age but also on dilution and organic

stress.

Spore tests for biological monitoring of antimicrobial activity of chemical sterilants are not available, therefore the best approach to monitor microbial killing efficacy is to estimate chemically the concentration of the active sterilant remaining in the used solution. Chemical test strips or liquid chemical monitors are available for determining whether an effective concentration of glutaraldehyde is present despite repeated use and dilution.

Acute or chronic exposure to glutaraldehyde can result in skin irritation or dermatitis, mucous membrane irritation (eye, nose, mouth), or pulmonary symptoms. Epistaxis, allergic contact dermatitis, asthma, and rhinitis also have been reported in healthcare workers exposed to glutaraldehyde. Healthcare workers can be exposed to elevated levels of glutaraldehyde vapor when it is used in poorly ventilated rooms, when spills occur, when glutaraldehyde solutions are activated or changed, or when open immersion baths are used. Therefore, as with all chemical disinfectants/sterilants, personal protective equipment (e.g., goggles and nitrile or butyl rubber gloves but not natural latex gloves) must be worn when handling glutaraldehydes.

Engineering and work-practice controls that can be used to minimize the degree of glutaraldehyde exposure include ducted exhaust hoods, air systems that provide 7–15 air exchanges per hour, ductless fume hoods with absorbents for the glutaraldehyde vapor, tight-fitting lids on immersion baths, and personal protection to minimize skin or mucous membrane contact.

If glutaraldehyde disposal through the sanitary sewer system is restricted, sodium bisulfate can be used to neutralize the glutaraldehyde and make it safe for disposal.

### ***Advantages.***

- Broad-spectrum.
- Excellent materials compatibility (noncorrosive to metals and does not degrade rubber and plastic).
- Relatively inexpensive.

### ***Disadvantages.***

- Solutions are highly toxic.
  - Require special ventilation.
  - Glutaraldehyde vapor monitoring recommended.
- Less reliable.
- Time consuming.
- Cannot be used with packaged items.
- Items must be rinsed with sterile water.
- The sterilization process with liquid chemical sterilants cannot be verified with biological indicators.
- Reduced activity in the presence of heavy bioburden; coagulates blood and fixes tissue to surfaces.
- Pungent and irritating odor.
- Relatively slow mycobactericidal activity.

### ***Uses.***

- Sterilization of heat-sensitive patient-care items.
- Should not be used as environmental disinfectants or as holding solutions for soaking items before cleaning.

### ***Hydrogen Peroxide [5-6, 82, 110]***

Hydrogen peroxide is active against a wide range of microorganisms and is a component of FDA cleared sterilants/high-level disinfectants. It is also an EPA- registered intermediate- and high-level disinfectant. If used to sterilize patient-care items, only FDA approved products classified as sterilants/high-level disinfectants should be used. All chemical sterilants/high-level disinfectants require immersion of the processed item within the chemical for the appropriate contact time as recommended by the chemical manufacturer.

Spore tests for biological monitoring of antimicrobial activity of chemical sterilants, however, are not available, therefore the best approach to monitor microbial killing efficacy of such solutions is to estimate chemically the concentration of the active sterilant remaining in the used solution.

Hydrogen peroxide is also used as an antiseptic because it serves as an antimicrobial oxidant and debriding agent for treating infection. Only formulations approved by the FDA for this purpose should be used. Hydrogen peroxide formulations have also been developed and found to be effective environmental surface cleaners and disinfectants. Some formulations are EPA registered as active against *Mycobacterium tuberculosis*, HBV, and HIV.

### ***Advantages.***

- FDA cleared sterilant/high-level disinfectant.
- EPA- registered intermediate- and high-level disinfectant.
- Broad antimicrobial spectrum.
- Does not coagulate blood or fix tissues to surfaces.
- Good cleaner for removal of bioburden.
- No activation required.
- Stable and effective intermediate-level disinfectant on environmental surfaces.
- No odor or irritation issues.
- Biodegradable- no disposal issues.

### ***Disadvantages.***

- Material compatibility concerns (brass, zinc, copper, and nickel/silver plating) both cosmetic and functional.
- Serious eye damage with contact.
- When used as a sterilant:
  - Sterility cannot be verified.
  - Cannot be used with packaged items.
  - Items must be rinsed with sterile water.

### ***Uses.***

- Sterilization of heat-sensitive patient-care items.
- Environmental disinfectant.
- Wound debridement.

## ***Iodophors [5-6, 82]***

Iodophors are EPA-registered intermediate-level antimicrobials (tuberculocidal) which may be used both as antiseptics and disinfectants. Iodophors are compounds of elemental iodine, iodide, or triiodide, and a polymer carrier. The amount of free iodine present determines the iodophor level of antimicrobial activity. Combining iodine with various polymers increases its solubility, promotes sustained release of iodine, and reduces skin irritation.

The best-known and most widely used iodophor is povidone-iodine. This product and other iodophors retain the germicidal efficacy of iodine but, unlike iodine, generally are nonstaining and relatively free of toxicity and irritancy. The pH, temperature, exposure time, concentration of total available iodine, and the amount and type of organic and inorganic compounds present affect the antimicrobial activity of iodine. Iodophors have significantly reduced efficacy in the presence of organic substances such as blood or saliva. Detergents are added to iodophor preparations used as surface disinfectants to enhance the cleaning ability of the solutions. The subsequent improvement in the surfactant properties make them excellent cleaning agents before disinfection and they have EPA- approved tuberculocidal activity as well.

Iodophors are prepared by combining iodine with a solubilizing agent or carrier. Dilutions of iodophors demonstrate more rapid bactericidal action than does a full-strength povidone-iodine solution; the reason for the observation that dilution increases bactericidal activity is unclear. Therefore, iodophors must be diluted according to the manufacturers' directions to achieve antimicrobial activity. Fresh solutions must be prepared daily because maximal tuberculocidal activity can be variable in solutions older than 24 hours. Diluting iodophor disinfectants in hard water may cause rapid loss of antimicrobial activity, therefore distilled water should be used to dilute iodophors.

Iodophors formulated as antiseptics contain less free iodine than do those formulated as disinfectants. Therefore, antiseptic iodophors are not suitable for use as hard-surface disinfectants because of concentration differences.

### ***Advantages.***

- EPA-registered intermediate-level disinfectants
- Broad-spectrum.
- Effective in dilute solution.
- Few adverse tissue reactions.
- Contains surfactant carrier that maintains surface moistness.
- Residual biocidal action.

### ***Disadvantages.***

- Unstable at high temperatures.
- Dilution and contact time critical.
- Daily preparation necessary.
- Discoloration of some surfaces (may be removed by wiping with alcohol).
- Rust inhibitor necessary.
- Inactivated by hard water.

### ***Uses.***

- Antiseptic.
- Disinfection of environmental surfaces and medical equipment.

## ***Phenolics [6, 82]***

Phenolic germicides are EPA-registered intermediate-level disinfectants for use on environmental surfaces and noncritical medical devices. Because of their toxicity, they are not used for antisepsis, and appropriate utility gloves should be worn when phenolics are handled.

Phenolics serve as good surface cleaners, and are effective in the presence of detergents. However, combinations of phenol in an alcoholic base, although EPA-approved as tuberculocidal disinfectants, are only fair to poor in cleaning surfaces. Thus when phenolic-alcohol disinfectants are selected for use, surface cleaning should be done initially with a water-based cleaning agent.

### ***Advantages.***

- EPA-registered intermediate-level disinfectants.
- Broad-antimicrobial spectrum.
- Useful on metal, glass, rubber, and plastic.
- Residual biocidal action.

### ***Disadvantages.***

- Can degrade certain plastics and etch glass with prolonged exposure.
- Difficult to rinse off certain materials.
- Residual film on treated surfaces.
- Discoloration of certain plastics
- Irritating to skin and eyes.

### ***Uses.***

- Surface disinfectant.

### ***Quaternary Ammonium Compounds [5-6, 82]***

EPA-registered quaternary ammonium compounds are low-level hospital disinfectants (non-tuberculocidal) which are good cleaning agents, but high water hardness and materials such as cotton and gauze pads can make them less microbicidal because of insoluble precipitates or cotton and gauze pads absorb the active ingredients, respectively. The newer quaternary ammonium compounds (i.e., fourth generation) purportedly remain active in hard water. These disinfectants may also be inactivated by organic materials and soaps. Therefore, although they may be appropriate for disinfection of floors and walls, they are less desirable for items more directly involved in patient treatment that may be contaminated with body fluids. The American Dental Association (ADA) Council on dental therapeutics even eliminated them from the ADA acceptance program as disinfectants in 1978. They are good cleaning agents, though, and may be used as such.

However, the addition of alcohol to quaternary ammonium compounds enhances their microbial activity to become tuberculocidal. If



such a product is EPA-registered, it may be used as an intermediate-level disinfectant. The alcohol component of such products seems to be primarily responsible for the extended antimicrobial spectrum, with the quaternary ammonium portion serving as the surface cleaning agent.

### ***Quaternary Ammonium Compounds (Alcohol-free)***

#### ***Advantages.***

- EPA registered as low-level disinfectants for non-critical surfaces.
- Cationic detergents- good surface cleaners.
- Pleasant odor.
- Low tissue toxicity.

#### ***Disadvantages.***

- Not tuberculocidal.
- Inactivated by anionic detergents (i.e. soaps and hard water).
- Inactivated by organic matter.

#### ***Uses.***

- Ordinary environmental sanitation of noncritical surfaces, such as floors, furniture, and walls.
- Disinfection of non-critical medical equipment.

### ***Quaternary Ammonium Compounds (With alcohol)***

#### ***Advantages.***

- EPA registered as intermediate-level disinfectants for environmental surfaces.
- Broad antibacterial spectrum.
- Rapidly tuberculocidal in 1-5 minutes.
- Available as prepared disinfectants.

#### ***Disadvantages.***

- Variable alcohol concentrations in different products can affect

surface-cleaning capabilities.

- Possible rapid evaporation from surfaces with solutions with high alcohol concentrations.

***Uses.***

- Disinfection of clinical contact surfaces.

## ENVIRONMENTAL INFECTION CONTROL

### Maintenance of Heating, Ventilation, and Air Conditioning Systems [2, 10]

Properly engineered heating, ventilation, and air conditioning (HVAC) systems require routine maintenance and monitoring to provide acceptable indoor air quality and to minimize conditions that favor the proliferation of health-care-associated pathogens. Preventive filter and duct maintenance (e.g., cleaning ductwork vents, replacing filters as needed, and properly disposing spent filters into plastic bags immediately upon removal) is important to prevent potential exposures of patients and staff during HVAC system shut-down.

#### ***Filters***

For optimal performance, filters within central HVAC systems require monitoring and replacement in accordance with the manufacturer's recommendations and standard preventive maintenance practices. In addition, the need to change the filter is indicated if the pressure required to push the air through the filter exceeds specifications (due to excess accumulation of dust and particulates). Filters also require regular inspection for other potential causes of decreased performance. Gaps in and around filter banks and heavy soil and debris upstream of poorly maintained filters have been implicated in health-care-associated outbreaks of aspergillosis, especially when accompanied by construction activities at the facility. Upon removal, spent filters can be bagged and discarded with the routine solid waste, regardless of their patient-care area location.

#### ***Ducts***

Ductwork in older health-care facilities may have insulation on the interior surfaces that can trap contaminants. This insulation material tends to break down over time to be discharged from the HVAC system. Additionally, a malfunction of the air-intake system can overburden the filtering system and permit aerosolization of fungal pathogens. Keeping the intakes free from bird droppings, especially those from

pigeons, helps to minimize the concentration of fungal spores entering from the outside .

Duct cleaning in health-care facilities has benefits in terms of system performance, but its usefulness for infection control has not been conclusively determined. No data indicate that duct cleaning, beyond what is recommended for optimal performance, improves indoor air quality or reduces the risk of infection. Duct cleaning has not been shown to prevent any health problems, and EPA studies indicate that airborne particulate levels do not increase as a result of dirty air ducts, nor do they diminish after cleaning, presumably because much of the dirt inside air ducts adheres to duct surfaces and does not enter the conditioned space . However if disinfection of ductal systems is attempted, only those chemical biocides that are registered for use in HVAC systems should be used. Sanitizers and/or disinfectants whose label indications do not specifically include the use of the product in HVAC systems to treat the surfaces of ductwork should not be used.

### ***Heating, Ventilation, and Air Conditioning System Shutdown***

Accumulation of dust and moisture within HVAC systems increases the risk for spread of health-care-associated environmental fungi and bacteria. If moisture is present in the HVAC system, periods of stagnation should be avoided. Bursts of organisms can be released upon system start-up, increasing the risk of airborne infection. Heating, ventilation, and air conditioning systems should not be shut-down for purposes other than required maintenance, filter changes, and construction. If airflow needs to be reduced, sufficient supply, return, and exhaust must be provided to maintain required pressure relationships when the space is not occupied.

Contingency plans in case of disruption of HVAC services should include back-up power generators that maintain the ventilation system in high-risk areas (e.g., operating rooms). Alternative generators are required to engage within 10 seconds of a loss of main power. If the ventilation system is out of service, rendering indoor air stagnant, sufficient time must be allowed to clean the air and re-establish the

appropriate number of air changes/hour (ACH) once the HVAC system begins to function again. Air filters may also need to be changed, because reactivation of the system can dislodge substantial amounts of dust and create a transient burst of fungal spores.

### ***Non-central Air-handling System***

Non-central air-handling systems are prone to problems associated with excess condensation accumulating in drip pans and improper filter maintenance. The filters in these units should be cleaned or replaced on a regular basis while the patient is out of the room.

### **Environmental Surfaces**

[2, 5, 10, 82, 105]

In the clinic, environmental surfaces are surfaces or equipment that do not contact patients directly but may become contaminated with patient material indirectly via contaminated hands or patient care items. Based on the potential risk of contamination, the various environmental surfaces can be divided into clinical contact surfaces and housekeeping surfaces. These two types of surfaces require different types of cleaning/disinfecting agents and protocols (see CHEMICALS USED for DISINFECTION and STERILIZATION in DENTISTRY). However, alcohol based disinfectants and high-level disinfectants should not be used to clean any environmental surface.

### ***Clinical Contact Surfaces***

Clinical contact surfaces are those surfaces which risk being contaminated with aerosols and spatter or touched with contaminated gloves during operation. Such surfaces include, but are not limited to, the dental chair, light handles, switches, dental radiograph equipment, dental chair-side computers, reusable containers of dental materials, drawer handles, sinks and faucet handles used for processing contaminated items, countertops, pens, telephones, and doorknobs.

Such surfaces, if contacted with contaminated gloves, can be potential reservoirs of microbial contamination. Dental health-care work-

ers' hands are the primary vehicle for spread of microorganisms from these surfaces to the nose, mouth, or eyes of patients and workers, as well as to instruments and other surfaces. This spread can be minimized by:

- a. Using impervious barriers to cover the surfaces during treatment, or
- b. Cleaning and disinfecting such surfaces after patient treatment.

### ***Barriers:***

When barriers are used to prevent cross-contamination, they must be removed between patients. A new set of barriers should be placed with each patient. Barriers should never be used for more than one patient.

After removal of the barrier, the surface should be examined. If the surface is found to have been inadvertently soiled, then it should be cleaned and disinfected before placement of clean barriers for the next patient.

Suitable materials for use as barriers include clear plastic wrap, bags, sheets, tubing, and plastic-backed paper or other materials impervious to moisture.

### ***Cleaning and Disinfection:***

Cleaning is using detergents or surface active agents to remove organic matter (e.g. saliva and blood), salts, and visible soils. The physical action of scrubbing with detergents and surfactants and rinsing with water removes substantial numbers of microorganisms. Furthermore, if a surface is not cleaned first, the disinfection process may be ineffective (depending on the type of disinfectant) because organic matter interferes with the action of some disinfectants. Removal of all visible blood and inorganic and organic matter can be as critical as the germicidal activity of the disinfecting agent (see *Chemicals Used for Disinfection and Sterilization in Dentistry*).

However, effective cleaning and disinfection may be time consuming

and difficult to achieve on some clinical contact surfaces. Furthermore, the level of microbial killing actually achieved by disinfection cannot be routinely determined in the clinic- i.e. it cannot be routinely determined how well the disinfectant is working. Therefore, covering surfaces with an impervious barrier is the preferred method of preventing cross-contamination from clinical contact surfaces.

However, even if barriers are used, general cleaning and disinfection of clinical contact surfaces, dental unit surfaces, and countertops is required at the end of the work session. If surfaces have become contaminated, then cleaning and disinfection is required after each patient. Cleaning and disinfection of clinical contact surfaces should be performed using the spray-wipe-spray technique. In this technique, the detergent/disinfectant is sprayed onto the surface, wiped clean, then sprayed on the same surface again and left untouched for the contact time specified by the manufacturer of the solution.

To reduce the risk of surfaces and objects becoming unnecessarily contaminated, equipment and supplies not needed during a particular patient's treatment should not be placed near the treatment area or on the counters.

### ***Housekeeping Surfaces***

Housekeeping surfaces are those surfaces which are less likely to be contacted with contaminated gloves but may become contaminated with aerosols, spatter, or spills. Examples of such surfaces are floors, walls, and hand washing sinks. Because housekeeping surfaces have limited risk of disease transmission, they can be decontaminated with less rigorous methods than those used on dental patient-care items and clinical contact surfaces. The majority of housekeeping surfaces need to be cleaned only with a detergent and water or an EPA-registered hospital disinfectant/detergent (see Chemicals Used for Disinfection and Sterilization in Dentistry), depending on the nature of the surface and the type and degree of contamination.

Floors and sinks should be cleaned daily, and walls, window coverings, and other vertical surfaces in healthcare areas should be cleaned and disinfected every 3-6 months. However, when housekeeping sur-

faces are visibly contaminated by patient material, prompt removal and surface disinfection should be carried out. Spills should be cleaned up immediately when they occur. Cleaning methods which produce minimal mists and aerosols or dispersion of dust in patient-care areas should be employed.

During cleaning and disinfection of environmental surfaces, DHCP should wear gloves and other PPE to prevent occupational exposure to infectious agents and hazardous chemicals. Chemical- and puncture-resistant utility gloves offer more protection than patient examination gloves when using hazardous chemicals.

Cleaning and disinfectant solutions should be prepared and stored correctly and in clean containers. The manufacturers' instructions for preparation and use should be followed closely. Solutions should be freshly diluted at the start of each work day. At the end of the day, any remaining solution should be discarded and the container scrubbed clean and allowed to dry to minimize bacterial contamination.

Cleaning solutions and cleaning tools (e.g., mop heads or cleaning cloths) may become soiled or contaminated during use and act as reservoirs for spread of contamination. Therefore mops and cloths should be cleaned and disinfected after use and allowed to dry before reuse. Single-use, disposable mop heads and cloths may be used to avoid spreading contamination. Non-disposable cleaning tools of the various areas within the healthcare facility (clinics, theatres, laboratories, hallways, offices, classrooms, and restrooms) should be separate and not mixed with those of other areas.

### ***Management of Spills***

In the event of spills of contaminated fluids ( e.g. blood, saliva, or pus), care should be taken not to spread the spill by wiping. Management of the spills should be as follows:

1. Cautionary signs should be placed around the area until it is completely cleaned and dried.
2. Cleaning personnel should use PPE throughout the procedure.



3. The contaminated fluid should be absorbed with absorbent paper towels or cotton.
4. The area should be washed with an appropriate detergent or disinfectant (see Chemicals Used for Disinfection and Sterilization in Dentistry) using disposable paper towels or large lumps of absorbent cotton, taking care to avoid overextending onto areas not affected by the spill. The disinfectant manufacturers' instructions should be followed regarding the need to pre-clean the area or not.
5. The area should then be covered with an acceptable disinfectant and left undisturbed for the proper contact time.
6. The disinfectant should, then, be removed by absorbing it with paper towels. Normal floor cleaning can then be resumed.

### Pest Control [2]

In healthcare settings, insects can serve as agents for the mechanical transmission of microorganisms, or as active participants in the disease transmission process by serving as a vector. Some of the microbial populations associated with insects in hospitals have even demonstrated resistance to antibiotics. Outbreaks of infection attributed to microorganisms carried by insects may occur because of infestation coupled with breaks in standard infection-control practices.

From a public health and hygiene perspective, pests should be eradicated from all indoor environments, especially health-care facilities. Insects should be kept out of all areas of the health-care facility, especially operating rooms and clinics. Insect habitats are characterized by warmth, moisture, and availability of food. Therefore, the pest management approach should focus on:

- a. eliminating food sources, indoor habitats, and other conditions that attract pests;
- b. excluding pests from the indoor environments; and
- c. applying pesticides as needed.

Doors communicating with the outdoor environment should close automatically when not in use. Windows should be sealed whenever possible. If windows need to be opened for ventilation, then screens should be in place, and in good repair.

A pest-control specialist with appropriate credentials should provide a regular insect-control program that is tailored to the needs of the facility and uses approved chemicals and/or physical methods.

## CLINICAL PRECAUTIONS DURING OPERATION

### The Aseptic Technique [5]

Avoiding exposure of DHCP and patients to blood and other potentially infective materials and surfaces through applying the aseptic technique is the primary way to prevent transmission of disease-causing microorganisms in dental health-care settings.

The aseptic technique is performing all tasks while maintaining the “aseptic to aseptic” relationship of contact, thus reducing or eliminating the spread of microbes. It is the concept central to any program of infection control, and it dictates that whenever handling patients, patient materials, or instruments and devices used during patient treatment, sterile, disinfected, and clean (aseptic) materials should not contact contaminated materials and vice versa. If such contact occurs, the barrier of infection control is broken and the possibility of cross contamination exists.

Examples of break in the aseptic technique are:

1. Use of unsterilized critical and semi-critical items during patient care.
2. Contaminated hands or gloves touching sterile, disinfected, or clean materials such as sterile instrument packages, dental chairs, packages, and bottles, dental records.
3. Sterile materials touching unsterile surfaces such as sterile patient instruments contacting uncovered bracket table, counter-top, or other non-sterile surface.

Each department and clinic of the college is unique in its working conditions and infection control requirements. DHCP, therefore, may encounter varying situations and challenges. Hence, even if particular situations are not specified in these guidelines, DHCP are required to exercise their judgment and apply the **aseptic technique** to all situations in which they come in contact with patients, patient materials, instruments, or devices used in patient care.

## Sterility of Patient Care Items

[2, 6, 10, 82, 95-96, 98, 100, 105, 108, 111]

All critical and semi-critical patient care items must be sterilized before being used to treat patients. Before opening instrument packages, the packages must be examined to ensure the seal is intact, and the integrity of the package is not broken in any way (e.g. through tears, perforations, or wetness).

After opening the package, the internal chemical indicator must be checked to ensure the sterilization conditions have been reached within the package (see Central Sterilization and Supply Department (CSSD)- PACKAGING). If the chemical indicator does not indicate that sterilization parameters have been met, the items should not be used for patient care and the package, along with the internal indicator, must be returned to the CSSD and the incident reported to the CSSD supervisor.

Dental handpieces and other intra oral devices attached to air or waterlines should also be sterilized between patients. Studies have indicated that the inner surfaces of high-speed handpieces and prophylaxes may become contaminated with patient material during function. The only effective way of cleaning the lumen of a dental hand-piece is to process it through a washer-disinfector with each lumen connected to a flushing system. Surface disinfection or immersion in high-level disinfectants is insufficient to adequately and safely process such devices. Furthermore, restricted physical access to the internal surfaces of the handpiece limits sterilization with chemicals; therefore, handpieces must be heat sterilized (autoclaved) between patients. Handpieces that cannot be sterilized should not be used.

Devices which come in contact with the oral cavity (e.g. apex locator tips, electric pulp tester tips, irrigating units, electrosurgery tips) should be sterilized if they are detachable and can withstand the sterilization cycle. If they are not sterilizable, such tips must be disposable or covered with a protective barrier. Chemical disinfection of items which enter the oral cavity is unacceptable.

Disposable items should be used whenever possible to avoid the need for barriers or sterilization. Needles and blades should never be sterilized and re-used between patients; only disposable needles and blades should be used.

If brush handles are not sterilizable, disposable brushes, Q-tips, or cotton pellets should be used instead. Disinfecting brush handles between patients is unacceptable.

### **Contacting Surfaces During Patient Care [5]**

During patient care, items which cannot be autoclaved such as computer monitors, keyboard and mouse, light-cure units, amalgamators, electric pulp testers, apex locators, etc. should not be touched with contaminated gloves. Devices such as these may be:

- a. covered with a barrier,
  - b. handled by overgloves,
- or
- c. handled by a circulating team member with uncontaminated hands.

However, if such items become inadvertently contaminated, they must be wiped with a disinfectant. Surface disinfection, though, should not be employed as the principle infection control measure for clinical contact surfaces because the level of microbial killing actually achieved by disinfection cannot be routinely determined in the clinic- i.e. it cannot be determined how well the disinfectant is working.

Anticipating the devices, items, and materials that will be used during patient treatment and preparing them beforehand greatly reduces the need to touch drawers and containers and other surfaces after the start of treatment; thus the potential for spread of contamination is reduced.

If however, the need to touch uncovered surfaces or packages arises, the operator's gloves should be removed prior to contacting such surfaces. If these items remain clean, then DHCP can touch them dur-

ing non-treatment periods safely without gloves.

An important point in maintaining the aseptic technique is to avoid leaving the work area unnecessarily with the protective wear in order to prevent contaminating clean zones via the contaminated protective wear. When transporting contaminated items to the CSSD, care should be taken to avoid touching surfaces with the contaminated items or gloves.

### **Work Practices [1, 10, 100]**

During preparation of the operating table, the 'unit dose concept' for supplies should be used; meaning materials should only be dispensed onto the table in the quantities needed with the containers kept away from the operating table to prevent the contamination of the containers and their contents. Cotton pellet dispensers and containers filled with unpacked gauze or cotton rolls should not be placed on the table. Furthermore, such materials should be used after the pack is opened immediately; any remaining amount, even if not removed from the pack, should be considered contaminated.

Sterilized burs should not be placed in an uncovered stand on the operating table or near the operating area. This will lead to their possible contamination with spatter or aerosols. Burs should be packed individually or in sets, according to the use, and only removed from the sterile pack immediately before use (see section on processing of instruments).

The use of a single endo box for multiple patients is unacceptable, as the contents of the box are considered potentially infected after it is opened. To reduce the amount of times the box contents are subjected to the sterilization cycle, single sets of files and broaches may be packaged individually inside autoclavable envelopes along with gauze to absorb the excess moisture and reduce the potential for corrosion.

Root canal treatment instruments can become contaminated with dental pulp containing nerve fibres, which may theoretically pose a risk of transmission of variant Creutzfeldt Jakob disease (vCJD). Since endodontic treatment instruments are difficult to clean, even with wash-

ing machines or ultrasonic cleaners, barbed broaches should be used once and discarded. No attempt to clean or sterilize barbed broaches should be carried out. Endodontic files, on the other hand, should be wiped with sodium hypochlorite after each insertion inside the canal so they are submitted for sterilization without any visible debris.

Glass slabs, dappen dishes, and metal mixing spatulas used for mixing should be sterilized between patients. Whenever possible, disposable paper mixing pads should be used instead. When using paper mixing pads, only the paper to be used should be dispensed to avoid contamination of the whole pad.

Sterile tweezers should be available for picking up wooden wedges, gutta percha cones, stainless steel bands and crowns, and other materials of which several of the items are stored together. This is to prevent contamination of the unused material. The sterile tweezers should be changed for each patient.

Reducing the amount of spray and spatter that exit the patient's mouth will reduce the amount of microbes contaminating the dental team. This can be accomplished by use of rubber dam isolation (when possible) and HVE during aerosol producing procedures (e.g. drilling, finishing, polishing, irrigation, and ultrasonic scaling), along with the regular suction tip (see the sections below on Reducing Aerosols and Droplets and the HVE and Saliva Ejector).

Having patients rinse their mouth before treatment with an antimicrobial mouthwash (e.g. chlorhexidine) for one minute can reduce bacterial counts significantly and thus reduce spread of bacteria through aerosols. Pre-procedural rinsing may also reduce the number of microorganisms entering the patient's bloodstream from the oral cavity after invasive procedures. Mouth rinses, however, only reduce the number of viable bacteria in saliva and loosely attached to mucous membranes; microorganisms within the gingival sulcus, nasopharyngeal passages, bloodstream, and DUWLs are not affected. Therefore, although rinsing reduces the amount of bacteria in aerosols, it does not eliminate the infectious potential of dental aerosols, and so pre-procedural rinsing must be used in combination with other protective measures.

## Engineering Controls

[5, 10, 112-113]

When dealing with blood-borne pathogens, engineering controls help to eliminate or isolate some of the hazards to DHCP. Engineering controls act on the hazard itself so that the employee may not have to take self-protective action. These controls are frequently technology-based and often incorporate safer designs of instruments and devices to reduce the risk of percutaneous and permucosal injuries. Examples of such designs include a mechanical device designed for holding the needle cap to facilitate one-handed recapping, needles with a needle-retraction mechanism, self-sheathing anesthetic needles, blunt suture needle, retractable scalpel, needleless IV systems, sharps containers, dental units designed to shield burs in handpieces, and tip-protection attachments to protect operator hands during insertion and removal of ultrasonic scaler tips and to shield the tips when resting in the hand-piece. Also, plastic irrigation tubes attached to disposable syringes may reduce the risk of injury when disposable syringes are used for irrigation procedures.

Desirable features to be sought in safety devices are :

1. The safety feature is an integral part of the device.
2. The device preferably works passively (i.e., it requires no activation by the user). If user activation is necessary, the safety feature can be engaged with a single-handed technique and allows the worker's hands to remain behind the exposed sharp.
3. The user can easily tell whether the safety feature is activated.
4. The safety feature cannot be deactivated and remains protective through disposal.
5. The device performs reliably.
6. The device is easy to use and practical.
7. The device is safe and effective for patient care.

Although each of these characteristics is desirable, some are not feasible, applicable or available for certain health care situations. For



example, a safety feature that requires activation by the user might be preferable to one that is passive in some cases. Each device must be considered on its own merit and ultimately on its ability to reduce workplace injuries. The desirable characteristics listed above should thus serve only as a guideline for device design and selection.

As safety devices become available in the market, they should be promptly assessed and considered for possible usefulness. A standardized screening and evaluation program may be implemented to assess such devices (see Acquisition of Devices and Materials).

### Work-Practice Controls

[1, 5, 10, 112]

Engineering controls are not always available or appropriate. And even when used, they do not completely eliminate the hazard risk to DHCP. Understanding the factors that influence the safety of a device and performing practices that will minimize the risk of exposures is also of critical importance. **Work-practice controls** are an alteration in the manner in which a task is performed which results in safer behaviors, reducing the likelihood of exposure. Examples of work-practice controls are use of personal protective equipment (e.g., protective eyewear, gloves, and mask), one-hand needle recapping, restricting use of fingers in tissue retraction or palpation during suturing and administration of anesthesia, removing burs before disassembling the handpiece from the dental unit, and minimizing potentially uncontrolled movements of such instruments as scalers or laboratory knives.

For procedures involving multiple injections with a single needle, the practitioner should recap the needle between injections by using a one-handed scoop technique if no engineering controls are available for resheathing the needle or holding the needle cover. Used needles should never be recapped or otherwise manipulated by using both hands, or any other technique that involves directing the point of a needle toward any part of the body. DHCP should never bend or break needles before disposal because this practice requires unnecessary manipulation. Before attempting to remove needles from non-

disposable syringes, the needles should be recapped to prevent injuries. Passing a syringe with an unsheathed needle should be avoided because of the potential for injury.

The use of sharps should be avoided whenever possible. For example, when disposable syringes are used for irrigation procedures, the needle (along with its cover) should be detached from the syringe. The solution may be expressed directly from the hub opening or a plastic irrigation tube may be attached to the syringe.

Work-practice controls for needles and other sharps also include disposing of used disposable syringes and needles, scalpel blades, and other sharp items in appropriate puncture-resistant containers located as close as feasible to where the items were used.

### **Reducing Aerosols and Droplets [1]**

The microbial content of aerosols, spatter, and droplet nuclei is derived from the oral cavity and DUWLs. Reducing the risk of infection requires reduction of the microbial content within these two sources and limiting the amount of aerosols and spatter which escapes the vicinity of the oral cavity. While no single approach can eliminate the risk of infection completely, several approaches using engineering and work-practice controls, used in combination can considerably reduce the risk of air-borne infections. The dental team should not rely on a single precautionary strategy.

In the reduction of dental aerosols, the first layer of defense is personal protection barriers such as masks, gloves and safety glasses. The second layer of defense is the routine use of an antiseptic pre-procedural rinse with a mouthwash such as chlorhexadine and reducing the microbial content within DUWLs (see section on Treatment of Dental Unit Waterlines). The third layer of defense is the routine use of a high-volume evacuator (HVE).

## The High-Volume Evacuator and Saliva Ejector

[1, 10, 103, 114]

Filtering the air within the clinics to reduce airborne microbial contamination has practical limitations and requires prolonged times to achieve adequate air circulation. Therefore the most efficient method to reduce airborne contamination is to control it before it escapes the immediate treatment site. The use of an HVE has been shown to reduce the contamination arising from the operative site by more than 90%. However, only suction systems which remove a large volume of air within a short period can be classified as HVEs. The wide bore suction hose attached to dental units is usually efficient enough to be classified as HVE, but the small opening of a saliva ejector does not remove a large enough volume of air to be classified as an HVE. Therefore, when aerosol generating procedures are being performed, the HVE should be used in addition to the saliva ejector, in order to minimize spread and inhalation of aerosols and endotoxins.

However care must be taken when using the low-volume saliva ejector because fluids and microorganisms may be retracted into the patient's mouth when:

1. A partial vacuum is created when the pressure in the patient's mouth is less than that in the suction tube. Such a condition can occur when:
  - a. a patient closes their lips around the tip of the ejector, or
  - b. during simultaneous use of the HVE close to the suction tip.
2. A length of the suction tubing holding the suction tip is positioned above the patient's mouth. Gravity may pull fluid back from the tube toward the patient's mouth.

This backflow can be a potential source of cross-contamination. Thus, to minimize backflow of oral fluids and microorganisms from the low volume saliva ejector:

1. Patients should not be allowed to close their lips tightly around suction tips to evacuate fluids from the oral cavity.

2. The HVE, when used simultaneously with the suction tip (as is recommended during aerosol producing procedures) should not be placed near the suction tip.
3. The tube should never be held at a higher level than the suction tip when the tip is inside the patient's mouth. This may be facilitated by bending the suction tip.

### **Transporting Contaminated Items [108]**

Contaminated items should be cleaned and disinfected as soon as possible after use. If the items will not be sent to the CSSD immediately, they must be kept in a holding solution. In the case of heavily contaminated items (e.g. those used for handling dental materials, scalers and cures, and oral surgical instruments), tissues, blood, and material debris should be removed (by wiping with gauze) as soon as possible, prior to transport to the decontamination area. All disposable items should be removed from the kit prior to transportation, e.g. disposable needles, cartridges etc.

After patient treatment, transport of contaminated items from the point of use to the CSSD should be in an appropriate container to minimize the risk of percutaneous injury. The container should be puncture resistant and of adequate size and depth for the items to be stable and rest safely within the container without protruding beyond its edges. The transport container should, preferably, be covered and of the type that can be locked, so that the courier will wear gloves in one hand and the other hand used to touch clean surfaces such as doorknobs. The transport container should be considered contaminated. During transport of items to the CSSD, the courier's gloves, contaminated items, and container should not contact any surface en route to the CSSD. Once the contaminated items have returned to the CSSD, the courier must remove the contaminated gloves and wash their hands or perform a disinfecting hand rub before contacting other surfaces and items.

### **Servicing Contaminated Items**

Contaminated equipment that needs to be serviced by maintenance or transported to another site outside the clinical halls and CSSDs

must be decontaminated first. Contaminated handpieces should not be serviced within the clinics because of the risk of cross-contamination between handpieces via the maintenance tools. Patient care items should be returned to the CSSD where they may be serviced after cleaning and decontamination and before packaging.

### **Storing Sterile Items in Clinics [105]**

If sterile items are stored in a patient-care area, they must be in covered or closed cabinets. Sterile packages should not be stored under the sink (or any location where they may become wet), on the floor, windowsill, or any area other than designated shelving or cabinets. Patient-care items should not be stored together with items not intended for clinical use. As a general rule, similar items should be stored together.

# INFECTION CONTROL IN RADIOLOGY

## Intra-Oral Radiography

[5-6, 10, 100, 105, 115-117]

Intraoral radiography involves direct contact with saliva which may contaminate the films, film holders, position-indicating devices, x-ray tube-head, door handles, as well as the timing controls and exposure switch. Thus, when taking radiographs, the potential to cross-contaminate equipment (including the processor and processing solutions) and environmental surfaces with blood or saliva is high if the aseptic technique is not practiced. Efforts at prevention of cross-contamination should be directed towards isolating or protecting:

1. items which directly contact the oral cavity, and
2. items which are contacted by the operator's hands (contact surfaces).

Infection control procedures should be carried out such that contaminated items should not leave the immediate vicinity of the x-ray rooms. All contaminated gloves, towels, and barriers should be disposed of in the vicinity of the x-ray room so as to not contaminate other areas. All areas beyond the x-ray room (especially the dark room) should be considered clean and maintained as such.

### ***Items Which Make Contact With the Oral Cavity***

Items which enter the oral cavity must be either sterilizable, disposable, or covered with a disposable barrier between patients. Such semi-critical items should never be processed between patients with disinfection alone. The following are items which contact the oral cavity during intra-oral radiograph making:

#### ***1. Operator's hands:***

The radiographer must wear gloves when making intraoral radiographs. Contaminated gloves must not contact any surface not protected by a barrier. If the operator needs to obtain more supplies, the contaminated gloves should not contact containers, drawers or other un-

protected surfaces. The contaminated gloves must be removed before touching such surfaces or a colleague may obtain the needed items.

Used gloves must be removed and hands washed before entering the dark room.

## ***2. Film packets:***

Intraoral films packets must be covered with a protective plastic barrier before being placed inside the patient's mouth. After removal from the patient's mouth, the excess saliva must be wiped off of the outer barrier and the film dropped out of the barrier onto a clean paper towel or into a clean plastic cup. The film must be dropped out without touching it with the contaminated gloves in order to maintain the film's cleanliness. The clean film can, then, be taken to the dark room and processed without contaminating the room's surfaces or equipment.

When the film packets are kept clean, aseptic processing in daylight loaders becomes easier and more practical. The clean films are inserted with the operator's hands through the cuffs of the daylight loader and processed with no resultant contamination of the loader, film holders, or solutions.

Aseptic handling of the films, protective barriers, and gloves must be ensured to avoid contamination of the dark room or daylight loaders. It is not acceptable to contaminate processor rooms or daylight loaders by introducing film packs or gloves still coated in saliva.

Due to the possible failure of barrier protection, new clean gloves should be used to transport the films to the dark room in their clean container.

## ***3. Film holding devices and position indicating devices:***

Film holding devices and position indicating devices should be either disposable and not reused between patients or they may be autoclavable and heat-sterilized between patients. Disinfecting such semi-critical items between patients is unacceptable and should not be attempted.

## **Contact Surfaces**

Contact surfaces are those surfaces touched by the radiographer during the making of intra-oral films. Such surfaces should be protected from contamination to avoid the need for repeated disinfection procedures which are time consuming and not full-proof (see ENVIRONMENTAL INFECTION CONTROL). However, in the event of surfaces becoming inadvertently contaminated, they must be cleaned and disinfected with the spray-wipe-spray technique. X-ray unit components, though, should not be sprayed directly as this may lead to a short-circuit so the wipe-discard-wipe technique should be used. They should be disinfected by generously soaking paper towels with the disinfectant and wiping the surface to reduce the microbial count, then wiping the surface again and letting the surface remain wet for the appropriate contact time. Although contamination of the following surfaces and items should be avoided, they should be cleaned and disinfected at the beginning and end of the work day.

The following surfaces are the most often touched contact surfaces:

1. X-ray tube-head
2. Control panel
3. Chair operating controls
4. Exposure buttons
5. Door handles

The above five components must all be covered by a barrier before making the radiographs. Barriers must be removed immediately after the patient exits the chair. Barriers should not be left in place until after processing of the films as this may lead to confusion whether the barriers are new or used.

6. Lead apron

Removal of the lead apron from the patient after making the radiographs leads to its contamination by the radiographer's gloves. Therefore, to avoid the need for cleaning and disinfection, the radiographer should not touch the lead apron with



gloves.

The apron should be placed onto the patient before donning the new gloves prior to radiograph making. After the end of the exposures, the method of removal of the lead apron depends on whether the radiographs were taken in the radiology department or in a clinic.

a. In the radiology department:

If the patient has not been asked to hold the film, the patient should be instructed to remove the apron and place it in its appropriate place. If the patient has been asked to hold the film, the radiographer should remove the apron after removal of the contaminated gloves.

b. In the clinics:

The radiographer should remove the apron after removal of the contaminated gloves.

### **Extra-Oral and Panoramic Radiography [6, 117]**

If they are not detachable and sterilizable, non-critical items used to stabilize and position the head such as ear rods, head positioners, and chin rests (i.e. items that contact intact skin) should be covered with a barrier or disinfected between patients.

Bite-blocks and any other item placed inside the oral cavity should be covered with a barrier or sterilized between patients. Disinfection of such items between patients is not sufficient; although they must be disinfected in the event of failure of the barrier isolation.

During extra-oral radiography, the operator's hands do not routinely contact the oral cavity. However, if the operator's gloves do become contaminated, then contact surfaces should not be touched and precautions must be taken as with intra-oral radiography.

## Digital Radiography

[6, 10, 105]

Digital radiography is a form of intra-oral radiography; therefore, the same infection control procedures apply to it as those pertaining to intra-oral radiography.

With digital radiography, sensors replace film packets. Sensors come into contact with mucous membranes and oral fluids; therefore they should ideally be sterilized. However, as of yet, there are no sterilizable digital sensors; therefore, sensors must be covered with disposable barriers between patients. If commercial barriers are not available, finger cots from latex gloves may be used to cover the sensor, and household plastic wrap used to cover the attached wire for a minimum length of 15 cm. To minimize the potential for cross-infection, after removing the barrier, the sensor should be cleaned and disinfected with an intermediate level disinfectant after each patient, but only according to the manufacturer's instructions.

The computer and work station components which may be contacted by the operator's gloves (e.g. keyboard, mouse, screen, and table) should also be covered with a barrier. These barriers must be changed between patients. The components of the digital system should never be transported between clinics before removal of barriers and, if necessary, disinfection.

Cleaning and disinfection of the components should be performed if failure of the barrier has taken place (i.e. if patient materials have contaminated the component). The manufacturer's care instructions should be consulted regarding appropriate disinfection/sterilization procedures for digital radiography sensors and components.

## Sialography [10, 82]

During sialography procedures, all clinical infection control procedures should be followed as described in the section Clinical Considerations. In addition, the following practices must be observed:

1. Probes which have contacted other surfaces in the oral cav-

ity should not be used to explore or dilate the salivary gland ducts so as to not introduce oral flora into the ducts. Only sterile probes and dilators should be inserted into the ducts.

2. Cannulas for injection of the contrast media into the salivary gland ducts should be used one time only then discarded. Due to the difficulty of cleaning and sterilizing long narrow lumens, cannulas should not be reused between patients.
3. Vials of contrast media used in sialography should preferably be single-dose vials. If single-dose vials are used, their left-over contents should not be reused.
4. If multi-dose vials are used, they should be handled in an aseptic manner and, before insertion of the needle, the rubber diaphragm should be cleaned with 70% alcohol. If sterility of the vial is compromised, it should be discarded.

## INFECTION CONTROL IN PROSTHODONTICS AND IN THE DENTAL LABORATORY

The practice of prosthodontics presents major challenges to the prevention of cross contamination. Dental prostheses or impressions can be contaminated with bacteria, viruses, and fungi. So, laboratory technicians and patients are frequently exposed to pathogens from dental impressions, stone casts, and appliances. Analysis of prosthodontic set-ups shows that many of the instruments and support equipment carry the potential to transmit disease but are not amenable to adequate sterilization or disinfection. The risk of potential disease transmission can be reduced by improving some of the disinfection and sterilization procedures used.

Dental impressions are contaminated with saliva and sometimes blood. Prostheses and appliances often are “tried in” in the process of their construction and thus go from laboratory to operatory and back again. Some items used routinely in dental laboratory may become contaminated, however, they pose problems of disinfection or sterilization such as shade guides, mold guides, indelible pencils, rulers, mixing spatulas, knives, face-bows, articulators, and torches. A number of these are composed of heat-sensitive materials and are subject to distortion. All aforementioned items are potentially infectious and must be disinfected or sterilized before handling in the laboratory. In addition, the routine cleaning and disinfection of environmental surfaces and equipment in the dental laboratory should be comparable to that practiced in the dental clinic.

A successful laboratory infection control program requires meeting three major criteria:

1. The use of proper methods for handling soiled items (**Aseptic Technique**).
2. The use of proper method and materials for decontaminating soiled items.
3. The establishment of a coordinated infection control program between dental clinic and dental laboratory. [5-6, 10, 21, 30,

## **The Use of Proper Methods for Handling Soiled Items**

**[5-6, 10, 27, 87, 118-123]**

To minimize the potential for cross contamination and disease transmission the following should be adhered to in the laboratory infection control program.

### ***Adherence to Standard Precautions***

Adherence to standard precautions includes hand hygiene and the use of personal protective equipments (see Standard Precautions).

### ***Personal Protective Equipment:***

Personal protective equipment (PPE) must be used when handling contaminated items in the laboratory. Depending on the task being performed PPE is indicated.

After decontamination of a laboratory item, the item can then be handled as noninfectious if separate clean working areas are available. However the use of a gown or laboratory coat is still recommended, and other barriers are often required as a safety precaution. The CDC, National Institute of Occupational Safety and Health (NIOSH) approved dust/mist face mask and eye protection or a face shield must be worn whenever operating lathes, model trimmers, or other rotary equipment.

### ***Task-Specific Designation of Work Areas***

The laboratory should be composed of clearly specified areas, with each area designated for particular tasks. Strict adherence to these designated purposes acts as a barrier system, reducing the potential for cross-contamination. Dental laboratories must operate using one of two general approaches to manage infection control:

1. Clean dental laboratory: The laboratory can be maintained as an isolated area and require all prostheses, impressions, and other laboratory work to be disinfected before entering the laboratory.

2. Standard dental laboratory: This method requires a receiving area to isolate, evaluate and decontaminate all materials entering the laboratory. The design of a standard dental laboratory should include the following areas:
  - a. Receiving area.
  - b. Production area.
  - c. Shipping area.
  - d. Consultation room.

***a. Receiving Area:***

The receiving area should be separate from the production area.

Persons working in the receiving area should wear a clean uniform or laboratory coat, a face mask, protective eyewear, and disposable gloves.

Personnel working in the receiving area should remove their PPE before moving to an uncontaminated area of the lab.

This receiving area should have running water and hand-washing facilities. Countertops and work surfaces should be covered with impervious paper if possible, cleaned and disinfected once or twice daily with an EPA-registered tuberculocidal (intermediate level) disinfectant according to the manufacturer's directions (see section on Chemicals Used for Disinfection and Sterilization).

Incoming cases should be unpackaged carefully and handled in an aseptic manner. Unless the case was labeled as disinfected in the dental clinic, it should be cleaned and disinfected immediately on receipt with an EPA-registered tuberculocidal disinfectant. Items should be disinfected before being transferred to case pans to avoid contamination of the pans. Case pans should be disinfected or sterilized after each use. Packing materials should be discarded to avoid cross-contamination.

***b. Production Area:***

Separate areas should be designated for new work and repairs in-

side the production area. If this area is separated adequately and all incoming cases are known to have been disinfected, DHCP can handle new cases as noninfectious once they have been decontaminated. Given the uncertainty of decontamination of devices that have been worn by a patient, full PPE should be used when handling these items, and every effort should be made to avoid cross-contamination from such items.

All work surfaces should be cleaned and disinfected with an EPA-registered tuberculocidal disinfectant on a regular basis but at least once or twice daily. Plastic wrap or other barrier can be used to cover work surfaces for simplifying cleanup.

Any instruments, attachments, and materials to be used with new prostheses/appliances should be maintained separately from those to be used with prostheses/appliances that have already been inserted in the mouth. Equipments should be cleaned and sterilized or disinfected as appropriate, usually once or twice a day and after each case for repairs. Disposable items are available, such as polishing wheels and brushes, eliminating the need for cleaning and disinfection of the reusable items.

### ***c. Shipping Area:***

This area is designed for final inspection, cleaning and disinfection of prostheses and appliances.

The disinfected devices should be shipped in a labeled and sealed plastic bag (information such as type of disinfectant used, disinfection method, and duration should all be mentioned). Disinfected acrylic items should be stored and shipped in a sealed bag containing a small amount of diluted mouthwash. Disinfected items should never be shipped in sealed bag containing disinfectant. Only new packing material should be used to avoid cross contamination.

### ***d. Consultation Room :***

If patients are seen in the dental laboratory for purposes of shade verification, infection control procedures must be the same as those used in the dental clinic, with proper cleaning and disinfection of work

surfaces after each patient appointment.

### ***Aseptic Technique***

Whenever handling patient materials, or instruments and devices, sterile, disinfected, and clean (aseptic) materials should not contact contaminated materials and vice versa. The laboratory technicians are required to exercise their judgment and apply the aseptic technique to all situations in which they come in contact with patient materials, instruments, or devices.

### ***Unit-dose Concept***

The dispensing of an amount of a material or device which is sufficient to accomplish the procedure and where excess may be discarded at completion, is commonly referred to as a “unit-dose.” Items such as denture adhesives for record trays, petroleum jelly, impression materials, waxes, pumice, and indelible pencils are amenable to unit -dosage with little or no change in the established routine.

Attention to when and by whom the material is dispensed is necessary to avoid breaking the aseptic chain.

### ***Barrier Technique***

Instruments such as face-bows, articulators, torch handles, and impression guns pose obvious problems for sterilization and disinfection and should be covered with a plastic barrier to prevent contamination.

### ***Avoiding Exposure Incident***

Laboratory personnel may be exposed to pathogenic microorganisms via:

1. Direct contact (through cuts and abrasions).
2. Aerosols created during lab procedures (inhaled or ingested).

The first layer of defense is personal protection barriers and the second layer of defense is the routine use of evacuation system. The use of sharps should be avoided whenever possible.



When gloves are worn during operation of a lathe, extreme caution must be taken to avoid injury resulting from the glove catching in the lathe.

Wearing masks, and safety shields (or protective eye glasses), and use of air-suction motors and ventilation systems are all required when operating mounted rotary equipment, such as lathes, to reduce the risk from aerosols, spatter, and projectiles.

The applied protocols and recommendations for vaccinating DHCP, and for post exposure management, must be observed (see sections on Vaccination and Occupational Exposure, Exposure Incident and Documentation).

Sharp items (e.g., burs, disposable blades, and orthodontic wires) should be disposed of in puncture-resistant containers (see section on Management of Medical Waste).

### **The Use of Proper Method and Materials for Decontaminating Soiled Items** **[2, 6, 10, 29-30, 118-120, 123]**

#### ***Steam Sterilization (Autoclave)***

Routine sterilization of items that can withstand heat enhances the overall laboratory infection control program and further reduces the potential for cross-contamination. Heat tolerant items used in the mouth and on contaminated laboratory items and materials should be cleaned and sterilized before being used for another patient or another laboratory case. Examples of such items are:

1. Metal impression trays
2. Burs
3. Rag wheels
4. Polishing points
5. Laboratory knives
6. Facebow forks

7. Handpieces and instruments
8. Polishing points
9. Water bath basins
10. Stainless steel bowels
11. Boley gauges
12. Metal rulers
13. Metal spatulas
14. Occlusal plane guides
15. Orthodontic pliers
16. Impression guns: It has been found that after routine clinical use, bacteria, including MRSA, heavily contaminated the impression guns. After the impression guns underwent disinfection after each use, there was a 6 % decrease in bacterial counts. The use of steam sterilization achieved sterility without harming the impression guns. Use of steam-sterilized impression guns with plastic impression gun covers for each patient decreased bacterial isolates by approximately 60 %. Use of steam sterilized impression guns plus plastic covers for each patient and disinfection after each use resulted in an approximately 95 % reduction in contamination.

### ***Disinfection***

For items that will come in contact with mucous membranes, but which are not used between patients (e.g., prostheses, custom trays, and occlusal and orthodontic appliances), intermediate- to high-level disinfection is sufficient, if laboratory infection control protocols are adequate to prevent cross-contamination. However, items which are used between patients, and which contact the mucous membranes, must be sterilized between patients. Heat-sensitive semi-critical items should be sterilized with chemical sterilants, or, at minimum, undergo high-level disinfection in the CSSD. Items that do not normally contact the mucous membranes but frequently become contaminated and cannot

withstand heat-sterilization should be cleaned and disinfected between patients and according to the manufacturer's instructions. Spray-wipe-spray method with phenolics or iodophors can be used for such items. Equipment particularly suited to this procedure are:

1. Articulators
2. Face-bows
3. Lathes
4. Case pans
5. Pressure pots
6. Water baths
7. Shade guide (spray-wipe spray with phenolics or iodophors)
8. Wooden-handled spatulas
9. Rubber mixing bowls
10. Torch

Contaminated materials and items used intra-orally that cannot be cleaned, sterilized, are to be discarded, for example:

1. Plastic impression trays
2. Custom trays
3. Disks
4. Brushes
5. Waxes

### ***Chemical Disinfectants***

Only EPA-registered hospital disinfectants with a tuberculocidal claim should be used. Examples of acceptable disinfectants are sodium hypochlorite ( in concentrations ranging from 0.05% to 0.5% (500 to 5,000 ppm) diluted with water) , iodophor (1% stock iodine diluted to the range of 0.05% to 0.5% in 70% isopropyl alcohol) and phenolics. Removable partial denture frameworks, acrylic resin impression trays, immediate dentures, and mold and shade guide teeth can be placed in

these solutions for adequate disinfection prior to use.

It should be cautioned; however, that occasional uptake of iodine stain has occurred in some acrylic resin denture teeth. This has not been observed after repeated disinfection of mold and shade guide teeth in the iodophor solution. If iodophors are used on shade guide, they should be wiped with water or alcohol after the exposure time to remove any residual disinfectant.

While removable partial denture frameworks have shown no evidence of corrosion in the sodium hypochlorite solution at the recommended concentration and time intervals, this solution should not be used on a regular basis due to corrosion potential.

Glutaraldehyde in 2% solutions is accepted as being effective disinfectants and unless used for 10 hours, is unacceptable for sterilization. The use of glutaraldehydes, however, is discouraged because they are toxic and require special precautions.

It is important to remember that most immersion disinfectants can only be used once before they should be discarded. Concentrations of solutions should be regularly assessed as dilutions will occur with time. Items should never be shipped or stored in chemical disinfectants.

### **Disinfection of Dental Impressions**

**[3, 6, 10, 21, 29-30, 119, 121, 124-146]**

Impressions and prostheses that have been inserted in a patient's mouth are contaminated with microorganisms. These can be transmitted to dental personnel either by direct contact or as aerosols produced during polishing and grinding procedures. This has obvious implications for cross contamination from the clinic to the laboratory.

Since impression material can act as a vehicle for the transfer of both bacteria and viruses, it has been recommended that impressions be cleaned and disinfected immediately after their removal from the mouth, in order to avoid contamination of dental clinic staff and dental technicians. Chairside rinsing of impressions is the first step in successful infection control in the laboratory.

Traditionally, impressions were rinsed under running water after being removed from the mouth to visibly eliminate saliva and blood. Although rinsing significantly reduces the numbers of microorganisms in most cases (one in vitro study showed that simple washing of an impression for 15 seconds produces approximately 90% reduction in the number of surface-resident bacteria), it does not decontaminate the impression. Although the intraoral effect of salivary mucins and other adhesive salivary proteins may tend to interfere with simple washing, rinsing impressions before and after disinfection is beneficial, in that it removes organic matter (blood, saliva, etc) that compromises the activity of some disinfectants, reduces the load of virus and bacteria, and removes residual disinfectant.

After rinsing, the impression should be disinfected using the proper material and method. Trimming the excess of impression material from noncritical areas might reduce the number of microorganisms and organic debris present. Given the porosity of impression materials, recommended exposure times probably should be greater than those for hard surfaces.

A small dimensional change or effect on the physical properties of the die stone may be within the acceptable range for the particular impression material or stone and thus have no clinically discernible effect on the final product. Some significant differences (e.g., increased hardness) are actually positive effects, resulting in an improved final product. Those dimensional changes may however be of clinical significance for procedures requiring a high degree of accuracy, for example in fixed prosthodontics. The materials respond differently depending on the disinfectant and the disinfection method used and it may therefore be appropriate that manufacturers recommend the use of particular disinfectants and the disinfection method for their products in order to ensure optimum dimensional accuracy and stability.

Impression materials marketed as containing a disinfectant still need to be rinsed and disinfected after removal from the oral cavity because the disinfectant may reduce the numbers of microorganisms, but does not totally eliminate those on the surface of the impression.

An alternative to impression disinfection is to sterilize the stone cast in any ethylene oxide sterilizer.

### ***Disinfection Methods***

The following techniques have been recommended for disinfection of impressions:

1. Spraying Method.
2. Short-term Submersion.
3. Immersion Method.

#### ***Spraying Method :***

The advantages of the spraying method are that the same disinfectant can be used to disinfect environmental surfaces, and less disinfectant is used. However, the spraying method poses the risk of not covering all surfaces of the impression because the disinfectant runs off and pools, and much of the impression is exposed to the disinfectant for only a brief time, rather than the exposure time recommended for disinfection. Furthermore, when the spraying method is used, the disinfectant can be released into the environment, increasing occupational exposure.

The impression must be sprayed with disinfectant on all sides until it is thoroughly wet and then covered (wrapped with plastic or otherwise enclosed) to avoid drying and allow exposure for the recommended disinfection time.

Some disinfectants, such as glutaraldehydes should never be sprayed, as the fumes may rapidly reach a lethal level. The fumes may also cause allergenic and other undesired reactions.

#### ***Short-term Submersion:***

Short-term submersion is an alternative method to spraying. The impression is immersed in the disinfectant solution and gently swirled for less than a minute and then kept in a closed plastic bag for the recommended disinfection time.

### ***Immersion Method:***

The immersion method is the preferred method of disinfection. Many clinicians have expressed concern that immersion in disinfectants for the recommended exposure time would result in distortion of hydrophilic materials because the impression imbibed water or disinfectant solution. Research has shown this latter concern to be clinically unfounded if short disinfection times are used, and in 1991, the ADA Council on Dental Materials, Instruments, and Equipment recommended that all dental impressions be disinfected by immersion.

The time for exposure to a particular disinfectant (i.e., the immersion time) should be at least that recommended by the product manufacturer for tuberculocidal disinfection. Impressions can be immersed in the disinfectant in a variety of containers including reusable plastic or glass containers that can be disinfected and disposable zipper-closure plastic bags.

The 1991 ADA council recommendation suggests use of disinfectants requiring no more than 30 minutes for disinfection. Impression materials that are hydrophilic should be disinfected with a product requiring a minimum time for disinfection (preferably no more than 10 minutes).

### ***Choice of Disinfectant for Impressions***

No single disinfectant is compatible with all impression materials. When selecting a disinfectant, one should consider the type of impression material, the disinfectants available in the dental clinic or laboratory, and the number of impressions to be disinfected per day. Table 14 lists the effect of various disinfectant treatments of impressions on the resultant cast dimensions. Disinfectants should not be used repeatedly for disinfection of impressions unless they are approved for reuse.

Where glutaraldehyde is referred to in this section, the 2% acid-potentiated glutaraldehydes or the 2% alkaline glutaraldehydes (not the neutral glutaraldehydes) are preferred, as they produce an improved cast surface. Conversely, a neutral glutaraldehyde should not be used because of potentially adverse effects on the surface quality. However,

the use of glutaraldehydes is discouraged because they are highly toxic and require special precautions when being used.

When using a newer disinfectant that has not been tested by research studies, in-house studies must be performed to ascertain compatibility with the impression materials. When considering methods of disinfection for impressions, two factors must be addressed:

1. The effect of the treatment on the dimensional stability and surface detail of the impression.
2. The effectiveness of the antimicrobial agent, and the deactivating effect of the impression material on the disinfecting solution, which could reduce the efficacy of the process.

Dental materials' manufacturers should be consulted regarding the compatibility with different disinfectants and disinfection methods not addressed in these guidelines.

**Table 14**

*Effect Of Disinfectant Treatment on Cast Dimensions as Compared with Room Temperature Controls*

DISINFECTANT	IMPRESSION MATERIAL			
	Alginate (Jeltrate)	Polysulfide (Permalastic)	Polysiloxane (Reflect)	Polyether (Impregum)
0.5% Sodium hypochlorite (Clorox)	NS*	NS	NS	NS
1% Sodium hypochlorite (Clorox)	NS	NS	NS	NS
0.5% Povidone-iodine (Betadine)	Significant difference†	NS	NS	NS
0.16% Halogenated phenol (CD-100)	Significant difference	NS	NS	NE*

\*NS denotes no significant difference ( $P > .05$ ), and NE denotes not evaluated.

†Significant differences ( $P < .05$ ) only in the anteroposterior dimensions as compared with room temperature controls.

*Source: Nisengard and Newman [21]*



## ***Elastomeric Impressions***

### ***Polysulfide:***

Continuing polymerization of some polysulphide impressions (which is a hydrophilic material) may contribute not only to dimensional changes observed over time, but also to adverse and inconsistent reactions with many of the disinfecting solutions. However, studies have shown that polysulfide impression material can be disinfected by immersion with most of the disinfectants recommended for use in dentistry without affecting accuracy and detail reproduction, but exposure time should be kept to minimum (10 minutes) (Table 15). One group of investigators found that immersion in disinfectants increases the wettability of polysulfide.

### ***Silicones:***

Studies have shown that addition silicone impressions can be disinfected by immersion with most of the disinfectants recommended for use in dentistry without affecting accuracy and detail reproduction (Table 15). A large number of studies found that the greatest accuracy was found with the addition-reaction silicone impressions. The greater accuracy and stability of the addition-reaction silicone materials make these the material of choice in many situations of enforced prolonged storage or immersion of impressions.

However, increasing the contact time between a surfactant-containing impression material and a disinfecting solution can significantly alter the resulting contact angle of the impression material and render it similar to a material depleted of surfactant. Whereas, following manufacturer recommended chemical disinfection times reduces surfactant loss and only minimally affects surface wettability.

It has also been found that immersion in disinfectants has no effect on the wettability of hydrophobic addition silicones, and decreases the wettability of hydrophilic addition silicones.

The evaporation of volatile by-products from condensation-reaction silicone materials may contribute not only to dimensional changes observed over time, but also to adverse and inconsistent reactions with

many of the disinfecting solutions. However, studies have shown that condensation-reaction silicone impressions can be disinfected by immersion with most of the disinfectants recommended for use in dentistry without affecting accuracy and detail reproduction.

**Table 15**

*Recommendations for Disinfection of Polysulfide and Silicon Rubber Impressions*

Accepted Disinfectant	Dilution	Time
Sodium hypochlorite 5.25%	1:10	10 minutes
Iodophors	1:213	10 minutes
Combination synthetic phenolics	1:32	10 minutes
Glutaraldehyde with phenolic buffer 2%*	1:16	10 minutes
2% Glutaraldehyde acidic*	1:4	30 minutes
Recommended method for disinfecting polysulfide and silicon rubber impressions : Immersion in an accepted disinfectant (for ≤30 minutes). * The use of Glutaraldehydes is discouraged because they are toxic and require special precautions.		

Source: Molinari and Harte [6], ADA [121], ADA [130]

### **Polyether :**

Although hydrophilic, polyether impressions can be disinfected by immersion, exposure times should be kept to a minimum (10 minutes). Therefore, polyether would not be the material of choice when complete sterilization is required.

Studies have shown that the effects of immersion disinfection on the dimensional stability of polyether impressions are not clinically relevant (dimensional accuracy measurements met the ADA standard of ≤0.5% dimensional change). Acceptable disinfectants for polyether impressions are listed in Table 16. One group of investigators found that immersion in chlorine dioxide disinfectants increases the wettability of polyether.

**Table 16***Recommendations for Disinfection of Polyether Impressions*

Accepted Disinfectant	Dilution	Time
Sodium hypochlorite 5.25%	1:10	10 minutes
Iodophors	1:213	10 minutes
Combination synthetic phenolics	1:32	10 minutes
Glutaraldehyde with phenolic buffer 2%*	1:16	10 minutes
Recommended method for disinfecting polyether impressions: Immersion (with caution) in an accepted disinfectant (not more than 10 minutes).		
* The use of Glutaraldehydes is discouraged because they are toxic and require special precautions.		

Source: *Molinari and Harte [6], ADA [121], ADA [130]*

### **Hydrocolloid Impressions**

#### **Irreversible Hydrocolloid (Alginate):**

Several studies have confirmed that alginates harbor significantly higher levels of bacteria than silicon rubber impressions. It is postulated that the porosity of alginate might account for this difference. Studies have also shown that viruses adsorb to alginate, making disinfection of paramount importance.

Recently, some manufacturers have begun incorporating disinfectant into their impression powder.

A number of investigators have evaluated the effect of disinfection of irreversible hydrocolloid (alginate) on dimensional accuracy, sometimes with contradictory results. Results showed differences based on the selection of alginate product and disinfectant. Differences noted were generally not clinically significant for most applications of casts retrieved from alginate impressions. Many studies showed that the dimensional accuracy of the gypsum casts made from irreversible hydrocolloid (alginate) impression is not significantly affected by the disinfection protocols (most of these studies used sodium hypochlorite in concentration

≤1% applied for ≤ 10minutes).

Disinfectant solutions also did not have an effect on the surface roughness of the cast. However, a significant increase in surface roughness was observed with increasing immersion time (≥5 minutes).

Furthermore, it has been shown that irreversible hydrocolloid impressions can be immersed up to 30 minutes in an iodophor without loss of clinically significant linear dimensional stability. Given the hydrophilic nature of the material, a minimal disinfection time should be used.

Some investigators, however, reported significant adverse effects on specific materials with disinfectants that are nonreactive with other alginates, suggesting that caution should be exercised. Hence, if fine accuracy is required, immersion disinfection of irreversible hydrocolloid materials produces unpredictable results. It is probable that the water used for the dilution of the disinfectants, rather than the disinfectant per se, is the factor causing the instability encountered with some hydrocolloid impression materials.

If dimensional changes are to be avoided or minimized, it appears that spraying the surface of the impressions or short-term submersion would be the viable methods of disinfecting irreversible hydrocolloid impressions.

The American Dental Association (ADA) recommended disinfecting alginates by immersion (not more than 10 minutes) in diluted hypochlorite (which has been shown by many studies to be an effective disinfectant for alginate impression), iodophor, or glutaraldehyde with phenolic buffer (a product that is no longer available) (Table 17).

### ***Reversible Hydrocolloid:***

For reversible hydrocolloid impression materials, a further possible source of contamination is the water bath used for liquefying and conditioning. The recommended temperature ranges used support bacterial growth, and the addition of a disinfectant solution to the water may solve the problem.

Research data suggest that there is no effect on dimensional accuracy of reversible hydrocolloid impressions immersed in various disin-

fectants (Table 17). However, immersion in 2% alkaline glutaraldehyde has a significant adverse effects on the impressions and resultant dies. Studies have shown that reversible hydrocolloid can be immersed up to 30 minutes in an iodophor without loss of clinically significant linear dimensional stability .

**Table 17**

*Recommendations for Disinfection of Hydrocolloid Impressions*

Accepted Disinfectant	Dilution	Time
Sodium hypochlorite 5.25%	1:10	10 minutes
Iodophors	1:213	10 minutes
Glutaraldehyde with phenolic buffer 2%*	1:16	10 minutes
Recommended method for disinfecting hydrocolloid impressions: Immersion (with caution) in an accepted disinfectant (not more than 10 minutes).		
* The use of Glutaraldehydes is discouraged because they are toxic and require special precautions.		

Source: Molinari and Harte [6], ADA [121], ADA [130]

### **Zinc Oxide Eugenol (ZOE) and Compound Impression**

**[6, 130]**

Limited data are available on disinfection of ZOE and compound impression. Adverse effects have been reported on ZOE immersed for 16 hours in diluted hypochlorite and on compound by all the disinfectant tested (hypochlorite, formaldehyde, and 2% alkaline glutaraldehyde).

Zinc oxide eugenol impression materials may be disinfected by immersion in glutaraldehyde or iodophor. The use of ADA accepted disinfectants that require no more than 30 minutes for disinfection is preferred (Table 18 ).

Spraying with phenolics, iodophors, or chlorine compounds can be used to disinfect impression compound.

**Table 18***Recommendations for Disinfection of ZOE*

Accepted Disinfectant	Dilution	Time
Iodophors	1:213	10 minutes
Glutaraldehyde with phenolic buffer 2%*	1:16	10 minutes
2% Glutaraldehyde acidic*	1:4	30 minutes
Recommended method for disinfecting ZOE impressions: Immersion in an accepted disinfectant (for ≤30 minutes). * The use of Glutaraldehydes is discouraged because they are toxic and require special precautions.		

Source: Molinari and Harte [6], ADA [121], ADA [130]

**Disinfection of Wax Bites, Wax Rims, Casts, Custom  
Impression Trays, and Bite Registration**  
**[6, 10, 21, 29, 120, 130, 147]**

***Bite Registration***

Wax rims should be disinfected by the spray-wipe-spray method using an iodophors or phenolics. Rinse-spray-rinse-spray, with most EPA-registered hospital-level tuberculocidal disinfectant, may be more appropriate for wax bites. After the second spray, they can be enclosed in a sealed plastic bag for the recommended time. These items probably should be rinsed again after disinfection to remove any residual disinfectant.

Chlorine compounds should not be applied to bite registration made of ZOE.

***Stone Casts***

Movement of microorganisms from the impression to dental casts has been demonstrated. Certain microbes have also been demonstrated to remain viable within gypsum cast materials for less than 7 days.

It is difficult to disinfect casts without damaging the cast. In order to

minimize the adverse effects on the cast, casts to be disinfected should be fully set (24 hours after pouring). The ADA recommends that stone casts be disinfected by spraying until wet or immersing in a 1:10 dilution of sodium hypochlorite or an iodophor (Table 19).

Immersion of set die stone in a 1:10 sodium hypochlorite or 1:213 iodophor solution has shown no, or minimal, undesirable physical effects on the stone. Casts should be rinsed after disinfection to remove any residual disinfectant, and they should be allowed to dry completely prior to handling (casts should be placed on end to facilitate drainage).

Casts can be sterilized in ethylene oxide sterilizer.

### ***Impression Trays***

Custom acrylic resin impression trays should be disinfected by spraying with a disinfectant or immersing in either 1:213 iodophor or 1:10 sodium hypochlorite (Table 19). They should be rinsed thoroughly to remove any residual disinfectant and allowed to dry fully before use. After use in the mouth, custom trays should be discarded. Metal trays should be steam sterilized after each use.

**Table 19**

*Recommendations for Disinfection of Stone Casts and Custom Impression Trays (Acrylic)*

Accepted Disinfectant	Dilution	Time
Sodium hypochlorite 5.25%	1:10	10 minutes
Iodophors	1:213	10 minutes
Recommended method for disinfecting stone casts and custom impression trays : Spraying until wet or immersion in an accepted disinfectant. Disinfectant for stone casts may be prepared using slurry water (saturated calcium sulfate)		

Source: Molinari and Harte [6], ADA [130]

## Disinfection of Dental Prostheses and Appliances

[5-6, 10, 21, 29, 120, 122]

### ***Removable Prosthesis and Orthodontic Appliances***

Prosthodontic and orthodontic appliances should be disinfected prior to delivery and before and after any laboratory adjustments. Prostheses or appliances that have been worn by patients and require repair should be handled as contaminated (even after disinfection) and cleaned thoroughly before disinfection by scrubbing with a brush and an antiseptic handwash chairside or by cleaning in an ultrasonic unit. The best time to clean and disinfect prostheses, or appliances is as soon as possible after removal from the patient's mouth before drying of blood or other bioburden can occur.

Severely contaminated prosthetic devices may have copious amounts of calculus and other tenacious bioburden. This material must be removed prior to attempts at disinfection, otherwise the decontamination process will not be effective. Immersion of the prosthesis in a beaker or plastic bag with stone and plaster removal solution, followed by placing it in an ultrasonic cleaner for 3 to 5 minutes, will remove most of the material. Cleaning and disinfection can, then, be performed.

Denture cleansers, including those made for ultrasonic cleaning in the dental office, are cleaners, and cannot substitute for appropriate disinfection. Some of these products now have limited antimicrobial activity; however, they cannot be assumed to eliminate all classes of microorganisms. After cleaning, the appliance is immersed in the chosen disinfectant for a minimum of 10 minutes.

The porous nature of acrylic makes such devices difficult to disinfect adequately. Given the tissue toxicity of glutaraldehydes and phenolics, iodophors or chlorine compounds are preferred for disinfection of acrylic appliances. Freshly diluted iodophor (povidone iodine), and chlorine-based compounds (sodium hypochlorite 5.25%) are the disinfectants most widely recommended for disinfecting those items. Because of the porous nature of the acrylic, periodic disinfection of repair work after grinding procedures is recommended. The clinician must be careful to



rinse the appliance thoroughly with water prior to delivery.

The ADA recommends sterilization of removable prostheses by exposure to ethylene oxide or disinfection by immersion in iodophors or chlorine compounds. Although both of these disinfectants are somewhat corrosive, studies have shown little effect on chrome-cobalt alloy with short-term exposures (10 minutes) to iodophors or 1:10 hypochlorite.

Prostheses should never be stored in a disinfectant before insertion. After disinfection and thorough rinsing, acrylic items can be stored in diluted mouthwash until inserted.

Orthodontic appliances can be handled in a similar manner. Any device that has been immersed in a disinfectant should be rinsed thoroughly before delivery to the patient.

### ***Fixed Prosthesis***

Fixed metal/porcelain prostheses are actually sterile following porcelain firing/glazing, but if they are not handled aseptically after this step, they must be disinfected before delivery to the patient.

Several clinical sources have confirmed that fixed prostheses may be disinfected by short-term immersion in diluted hypochlorite without apparent harm to the device. The higher the content of noble metal, the less the likelihood of adverse effects on the metal. However, care should be taken to minimize the exposure times of metals to potentially corrosive chemicals.

Unglazed porcelain should not be exposed to any disinfectant; the process of porcelain firing/glazing will sterilize the porcelain.

Fixed metal prostheses can be sterilized by autoclaving if desired. Table 20 is a summary of the recommended disinfection protocols for prosthodontic and orthodontic appliances.

**Table 20**

*Recommendations for Disinfection of Prosthodontic and Orthodontic Appliances*

Appliances	Method	Accepted Disinfectant	Dilution	Time
Metal/acrylic All metal	Immersion/ spray until wet	Sodium hypochlorite 5.25%	1:10	10 minutes
		Iodophors	1:213	10 minutes
Removable (acrylic/ porcelain)	Immersion	Sodium hypochlorite 5.25%	1:10	10 minutes
Removable (metal/ acrylic) Fixed (metal/porcelain)		Iodophors	1:213	10 minutes
Never expose unglazed porcelain to any disinfectant				

Source: *Molinari and Harte [6]*

### **Sterilization of Dental Impressions, Stone Casts, and Dental Prostheses and Appliances** [82, 148-154]

Sterilization of impression materials; stone casts; and dental prosthesis and appliances have been recommended to minimize cross-contamination in the dental facility. Although, there are few reports about the effect of sterilization on these items. In addition to high-temperature sterilization (e.g., autoclave), low-temperature sterilization (e.g., hydrogen peroxide gas plasma, ethylene oxide gas, and immersion in 2% glutaraldehyde for 10 hours) which is used for heat- and moisture-sensitive devices have been suggested for sterilizing dental impressions; casts; and dental prosthesis and appliances. Microwave oven irradiation can also be used to sterilize rubber impression, gypsum casts and acrylic prosthesis, and it has proved to be an effective method. However, it might affect the porosity of the acrylic appliances.

It has been shown that sterilization (using autoclave, ethylene oxide gas, immersion in 2% glutaraldehyde for 10 hours, and microwave radiation) reduces the reproducibility of rubber impressions. However, the effect of microwave sterilization on both accuracy and wettability was small. Furthermore, analysis of dimensional changes by another study showed that casts made from impressions sterilized by ethylene oxide are acceptable for use in the construction of fixed or removable prostheses. The drawback effects of autoclave sterilization could be overcome by using ceramic trays rather than custom trays and by spraying impression surfaces with surfactant before pouring the gypsum mix. Glutaraldehyde still degraded dimensional accuracy even with ceramic trays and surfactant.

When the effects of autoclave sterilization on dental elastomeric impression materials (polysulfide, polyether, condensation silicone, addition silicone) were examined, the surface roughness and accuracy of the impressions have been shown to be minimum with addition type silicone impression materials. However, another study showed that the accuracy of polyvinyl siloxane impression had been affected by sterilization in a steam autoclave and it can be used for the fabrication of diagnostic casts and some transitional prostheses, but not for routine construction of crowns or fixed partial dentures.

At least one addition type polyvinyl siloxane impression material is marketed as being autoclavable without affecting the impression reproducibility when used in a rigid reinforced polycarbonate impression tray or in a metal tray.

### **Communication with the Dental Laboratory**

**[6, 10, 155]**

The dental practitioner should communicate with the dental laboratory regarding infection control procedures used in the dental clinic. Communication and understanding can help to avoid duplication of effort and possible adverse effects on the materials. When a case is transported from and to the dental clinic or dental laboratory, DHCP should provide written information regarding the methods (e.g., type of

disinfectant and exposure time) used to clean and disinfect the material (e.g., impression, stone model, or appliance); otherwise, the laboratory or dental clinic should assume that the case is contaminated and disinfect as appropriate.

If during manipulation of a material or appliance a previously undetected area of blood or bioburden becomes apparent, cleaning and disinfection procedures should be repeated.

Transportation of contaminated items should be in a closed, leak proof container which is either colored or identified with a biohazard label. The CDC guidelines state that laboratory materials should be cleaned and disinfected before being manipulated in the dental laboratory as soon as possible after removal from the patient's mouth before drying of blood or other bioburden can occur.

The American National Association of Dental Laboratories (NADL), which has been instrumental in the development of infection control protocols for dental laboratories, recommends disinfecting all items received from the dental clinic and disinfecting all appliances before shipping. NADL recommends that all items be shipped in heat-sealed bags (to and from the laboratory).

# INFECTION CONTROL IN RESEARCH ANIMAL FACILITIES

## Zoonotic Considerations

[2, 156-157]

The presence of research animals in health-care facilities must be accompanied by consideration for the potential transmission of zoonotic pathogens (pathogens transmitted from animals to humans) in these settings.

Zoonoses can be transmitted from animals to humans either directly or indirectly via bites, scratches, aerosols, ectoparasites (a parasite that lives on the exterior of its host), accidental ingestion, or contact with contaminated soil, food, or water. Over 150 diseases may be classified as zoonotic. Many of these diseases are of great concern and include rabies, herpes B virus, tuberculosis, hepatitis, Q fever and cat scratch fever. Table 21 shows examples of diseases associated with zoonotic transmission from different animals which may be used in research animal facilities. Such diseases often do not cause obvious signs and symptoms in one species but may cause significant illness in another species. Therefore, standard precautions should be applied and staff members should follow safe work practices rigorously whenever working with animals, even though they may not show signs of illness.

Animals potentially can also serve as reservoirs for antibiotic-resistant microorganisms, which can be introduced to the health-care setting while the animal is present. Another potential source and mode of transmission of zoonotic pathogens in health-care settings which must be taken into consideration is colonization of the hands of health care workers by pathogens acquired from pets in their homes.

Another health concern which must be considered in animal research facilities is Laboratory Animal Allergy (LAA). Although not infectious in origin, these reactions are significant and must be addressed because they are among the most common conditions affecting the health of workers involved in the care and use of research animals. Several species of animals commonly used in animal research and teaching are

also species that frequently cause allergic reactions in people. Among these species are the cat, rabbit, rat, mouse, and dog.

**Table 21**

*Examples of Diseases Associated with Zoonotic Transmission+*

Infectious disease	Cats	Dogs	Rabbits	Rodents
Viruses				
Lymphocytic choriomeningitis				+
Rabies	+	+		
Bacteria				
Campylobacteriosis	+	+		+
Capnocytophaga canimorsus infection	+	+		
Cat scratch disease (Bartonella henselae)	+			
Leptospirosis	+			+
Pasteurellosis	+	+	+	
Plague	+			+
Q fever (Coxiella burnetti)	+			
Rat bite fever (Spirillum minus, Streptobacillus moniliformis)				+
Salmonellosis	+	+	+	+
Tularemia	+		+	+
Yersiniosis			+	+
Parasites				
Ancylostomiasis	+	+		
Cryptosporidiosis	+			

Giardiasis	+	+		
Toxocariasis	+	+		
Toxoplasmosis	+	+		
Fungi				
Blastomycosis		+		
Dermatophytosis		+	+	+

+ This table does not include vectorborne diseases.

§ Rodents include hamsters, mice, and rats.

¶ The + symbol indicates that the pathogen associated with the infection has been isolated from animals and is considered to pose potential risk to humans.

*Source: adapted from Schulster, et al. [2]*

## Administrative Considerations

### [2, 156-157]

It is the responsibility of the principal investigator of each animal care facility to approve a documented standard operating procedures protocol which ensures that all workers under their supervision (co-investigators, staff, students and volunteers) handling animals or unfixed animal tissue in the research laboratory are informed of the potential dangers involved in contact with animals or unfixed animal tissue, and are aware of the procedures available to prevent and treat such hazards.

The operational protocol should include:

1. Training of animal handlers to recognize the signs and symptoms related to the zoonotic diseases that could potentially be transmitted by the species of animals used in the facility.
2. Animal handling and how to work safely with animals.
3. Daily animal husbandry (e.g., protection of the employee while facilitating animal welfare).
4. Management, cleaning, disinfecting and/or sterilizing equipment and instruments.

5. Employee training for laboratory safety and safety procedures specific to animal research worksites.
6. Spill cleanup, and waste management.
7. Management of injuries.

In addition, established College of Dentistry infection control and safety guidelines should be incorporated in the protocol as minimum standards for personal protection, engineering controls, work-practice controls, disinfection and sterilization.

The operational protocol should also include a clear policy regarding vaccinations and routine testing of workers. The policy must be approved by a certified veterinarian, and must address:

1. The availability of pre-exposure vaccines.
2. The need for routine tuberculosis testing.
3. Baseline serums.
4. Hearing and respiratory testing.
5. The need for pre-contact and post-employment testing.
6. Treatment to be provided for symptoms or injuries related to animal allergens, bites, scratches, or other animal hazards.
7. An exposure incident report (formulated by the appropriate health officials).

It is the responsibility of the principal investigator in a research facility (Director of the Research Chair) to ensure appropriate employee occupational health services are available to workers in the facility. Health programs specific to the animal research facility must be established, and management of postexposure procedures specific to zoonoses must be coordinated with the occupational health service. All necessary vaccinations, examinations, and treatment related to occupational zoonoses must be provided to the employees by the health service.

Any employee who has an autoimmune disease (no matter how well managed) or is taking immune suppressing medications or is pregnant or planning conception should inform the occupational health service



physician in order to analyze the specific medical concerns for the employee in relation to the workplace hazards so as to make recommendations for accommodating the employee.

The standard operating procedures protocol must be disseminated to all workers. New workers must be made aware of the contents of the document before commencing work in animal facilities.

### **Engineering Controls**

**[2, 156]**

All animals facilities should have proper ventilation achieved through appropriate facility design and location. Animal rooms should be kept at negative pressure relative to the surrounding corridors. The air should be expelled to the outside environment, not recirculated through the facility. The doors to animal research rooms should be kept closed and access to animal facilities restricted to essential personnel.

When there is a very high potential for aerosol generation, additional facility related engineering controls such as sealed penetrations through the walls, double door access to the rooms, or installation of high efficiency particulate air (HEPA) filters in the exhaust air system may be necessary. A facility can also apply engineering controls locally in the form of containment devices to reduce aerosol spread. All devices and filters need to be certified and leak tested annually. When applicable, biological safety cabinets may be used to provide near sterile work environments that offer protection to the worker, the materials they are manipulating, and the work area itself.

To maintain facility safety, the director should also review the research protocols and, based on the anticipated procedures and risks, the necessary engineering controls should be made available to conform with Infection Control Guidelines of the College of Dentistry (see section Engineering Controls).

### **Animal Quarantine and Stabilization**

**[2, 156]**

Only animals obtained from quality stock should be used or incom-

ing animals should be quarantined to detect zoonotic diseases. Quarantine is the separation of newly received animals from those already in the facility until the health of the animal has been evaluated. The quarantine period should be of sufficient duration to allow expression of diseases present in the incubation stages. Some or all of the following should be achieved during the quarantine and stabilization period: diagnosis, control, prevention, and treatment of diseases; physiological and nutritional stabilization; and grooming to include ectoparasite control. All sick animals should be treated or removed from the facility. Animals in which no disease has been detected should have routine prophylactic vaccinations and kept under the regular care of a trained person and a veterinarian.

### **Staff Considerations**

**[2, 10, 156-157]**

Access to the laboratory or animal facility should be limited to animal-care staff, researchers, environmental services, maintenance, and security personnel. All people with access to the facility must be advised of the potential risks. Immunocompromised persons or those for whom infection might be unusually hazardous should not have access to the animal room.

Personnel within the facility should always wear personal protective equipment (PPE) (at the minimum: laboratory coat, gloves, mask and eye protection or face shields) when working with animals. The laboratory director must ensure the appropriate PPE for the tasks performed within the lab are provided.

In addition to protecting against splashes and spatters and providing protection for eye and mucus membranes, proper use of PPE can greatly reduce the allergenic effects of animals in sensitive persons. In addition, use of PPE can prevent sensitization in someone who is not originally allergic to laboratory animals. All PPE (including lab coat) must be removed before leaving the animal housing area.

Lab coats and other PPE should be removed before leaving the animal housing area, and should be changed whenever damaged or visibly soiled.

## Work Practices and Procedures

[2, 156-157]

The laboratory and animal rooms should be posted with hazard warning signs incorporating the following:

1. Universal biohazard symbol.
2. A list of the animals in use.
3. The personal protective equipment to be worn in the room.
4. Special required practices.
5. The names and phone numbers of persons to contact in case of emergency.

There should be no eating, drinking, or smoking in areas where animals are used. Food must be stored in a separate refrigerator maintained for this purpose only and located outside of the area where animals are used or housed. Handling contact lenses and applying cosmetics should also be avoided in laboratories, as well as any other activities that might involve hand-to-mouth or hand-to-eye contact.

When handling animals, standard precautions and the aseptic technique should be observed at all times. Work-practice controls should be used as applicable to the specific tasks (for examples see section Work-Practice Controls). Contact with animal saliva, dander, urine, and feces should be minimized as much as possible. Staff members should perform all manipulations of potentially infectious materials so as to minimize aerosol production.

All work surfaces must be decontaminated after any animal use and at the end of the workday. Environmental surfaces should be cleaned thoroughly and disinfected by using an appropriate cleaner/disinfectant (see sections Environmental Infection Control and Chemicals Used for Disinfection and Sterilization in Dentistry).

Contaminated materials which will not be decontaminated in the laboratory itself must be placed in containers that are both leak proof and durable before they are removed from the laboratory. Disposable equipment should be used whenever possible. Reusable instruments

that come in contact with the animal must be sterilized. Instruments which have been used on animals should be restricted in future use to animals only.

Careful hand washing must be done after handling animals , after removing gloves or other PPE, and prior to leaving the laboratory, procedure room, or animal room for any reason.

### **Exposure Incident**

**[2, 156-157]**

In case a worker experiences any of the following:

- Being bitten or scratched while working with an animal
- Experiencing signs and symptoms consistent with a work related exposure to an animal or an infectious organism being studied
- Known exposure to a zoonotic disease
- Scratches, bites, or other breaks in the skin,

the skin should be cleaned and treated immediately, and the appropriate action must be taken as described in the standard operating procedures protocol approved by the appropriate occupational health service.

The incident must be reported to the lab supervisor and to the infection control officer. the exposure incident report must be filled out by the worker or his/her supervisor and signed by both. The supervisor or director must then arrange for immediate medical evaluation, treatment, and subsequent surveillance as needed. All records of the incident and subsequent tests and clinical examinations must be provided to the infection control officer.

At-risk personnel should inform supervisors of any febrile illness as part of ongoing surveillance for potential laboratory associated infections. In addition, the director should maintain appropriate written records of all unintentional releases, spills, and exposures to biohazardous materials.

# CENTRAL STERILIZATION AND SUPPLY DEPARTMENT (CSSD)

## Location and Design of the CSSD

[10, 17, 108]

Cleaning and sterilization of instruments should be carried out in a designated area, the Central Sterilization and Supply Department (CSSD) away from the clinic environment. The location and design of the CSSD must be carefully planned in order to facilitate maintaining strict standards of instrument sterilization and environmental infection control. Entry to the CSSD should be restricted to authorized staff only.

### ***Location of the CSSD***

The CSSD should be easily accessible for clinical staff; but it must be in a low-contamination area away from common walkways or traffic flow. There should be a designated changing area in close proximity to the CSSD for staff changing into work attire.

The CSSD should be separated from the external environment; no doors should open onto the outside of the building and, if windows are present, they should not be opened. This separation is to protect the CSSD from dust and other external elements.

### ***Workflow Pattern***

The CSSD should be separated into four areas. These areas (from the highest contamination to the lowest contamination) are:

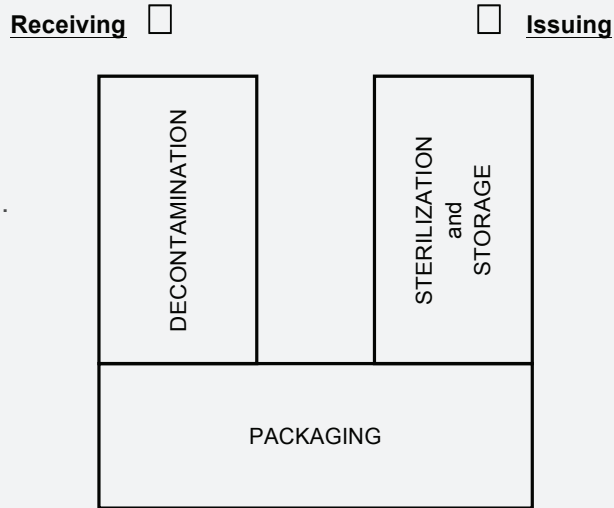
1. The decontamination area.
2. The packaging area.
3. The sterilization area.
4. The storage area.

These areas should be physically separated from each other by walls (with connecting doors or windows) or partitions in order to reduce the risk of re-contamination of processed items and devices (Fig-

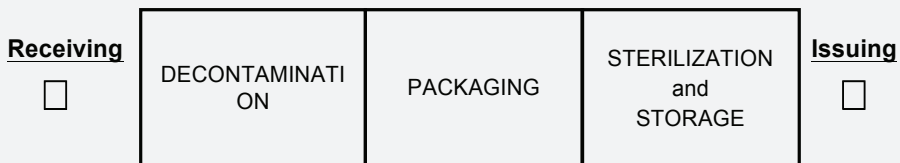
ure 3). The CSSD should have separate receiving and issuing windows physically separated from each other. The receiving window should be located in the decontamination area while the issuing area should be located in the storage area.

**Figure 3**

*Diagrams of Recommended CSSD Work-Flow Patterns*



*U- shaped workflow pattern*



*Linear workflow pattern*

Personnel staffing one area should not cross over to the other area and back. The floor plan of the CSSD should allow transport of the processed items from one area to the next without the need for staff to exit their station. Once a staff member from a lower contamination area

enters a higher contamination area, they must not return to the lower contamination area without removing all personal protective attire and washing hands well.

Furthermore, trays or containers used to transport items from one area to another must be considered to be of the same degree of contamination as the items they contain. They must be processed in the same way the items are and should never go against the traffic flow of the processing; i.e. they should never go from areas of low contamination to areas of high contamination. Such containers should be sterilized before being used again, but do not need to be packaged prior to sterilization. After sterilization, they must be stored in clean, closed cabinets or drawers in the storage area. Although they are not considered sterile (because they are not in sealed packages), they may thus be considered clean, and may be used to transport packaged sterile items from the CSSD to the clinics.

### ***Design of the CSSD***

The following features must be available in CSSDs:

1. Sufficient size to accommodate all of the devices, accessories, cabinetry, storage areas, and personnel necessary for the convenient flow of the work while maintaining adequate separation of the different work areas (see Workflow Pattern).
2. Good ventilation and air conditioning to control the heat generated by the sterilizers and other machines as well as for elimination of chemical fumes (see Section Heating, Ventilation, and Air Conditioning Systems in Health-Care Facilities).
3. An uncontaminated work station for office work and documentation.
4. Flooring of materials which are seamless, smooth, non-porous, non-slip, scrubbable, non-adsorptive, non-perforated, and capable of withstanding repeated cleaning with harsh chemicals. The surface of the floors should be self-finishing and require no protective coating for maintenance. The flooring material should be medical grade vinyl for the packing and storage area. Floors

- of decontamination area may be of epoxy or vinyl.
5. Ceiling of packing area and sterilization and storage areas should be a single seamless surface, not squares, non-perforated, and amenable to cleaning. The ceiling is preferable to be of medical grade stainless steel.
  6. Walls and countertops of highly polished, non-porous, scrubbable, non-adsorptive, non-perforated, seamless surfaces resistant to heat, chemicals, and moisture so as to be amenable to repeated washing and/or disinfection with harsh chemicals.
  7. Antibacterial paint for walls of the decontamination area.
  8. Countertops and cabinetry of adequate size and space to accommodate table-top devices and other work items.
  9. Moisture-resistant cabinetry.
  10. Multiple electric outlets.
  11. Multiple water lines for the various sinks, washers, and sterilizers. The water quality should be such that the total dissolved solids is less than 20.
  12. Floor drains placed in the area of highest contamination risk.
  13. Hands-free controlled handwashing sink, trash receptacle, dispensers for soap and disinfectant solutions, and paper towels in each area, as well as adjacent to the receiving window on the outside of the CSSD.
  14. An eye rinse station and an ER kit for management of percutaneous injuries in each area.
  15. Closed storage areas of adequate size and number to accommodate the various sizes, types, and number of items to be stored in the CSSD. Storage areas must be closed from all sides to protect the sterilized packages from the surrounding environment.
  16. Storage facilities for bulk items should be provided external to, but near to, the designated CSSD.



17. Conveniently positioned hands-free trash receptacles in each area.
18. A set of housekeeping cleaning items (towels, mops, containers, etc.) for cleaning of work surfaces and housekeeping surfaces should be available in each area; these cleaning items should be stored in an isolated cabinet.
19. Required personal protective equipment should be easily accessible in each of the work areas.

The following are other features specific to the different CSSD areas:

### **1. The Decontamination Area:**

The decontamination area should contain waste containers (bio-hazardous and regular) and sharps disposal containers near the entry point of the received items. Instrument processing sinks, holding solutions, ultrasonic cleaners, and washers/thermal disinfectors (along with the necessary detergents, disinfectants, towels, and brushes, containers and baskets) should also be placed in this area. The sinks should be large, deep, and with hands-free controls. Sink and water controls must both be of a surface resistant to moisture and chemicals.

Air and water lines should be available for running handpieces during cleaning and lubrication.

Access to the decontamination area is preferably through dedicated changing rooms provided with hand hygiene facilities and lockers.

### **2. The Packaging Area:**

The packaging area should contain the packaging materials, heat sealers, sealing (autoclave) tape, chemical indicators, biologic indicators (see Sterilization Monitoring), as well replacement instruments, burs, and instrument cassettes (for replacement of defective or missing items in functional sets). Gauze pads and rust inhibitors should also be available in this area. Lubricants should be available, as well as air and vacuum lines, for running handpieces during cleaning and lubrication, if necessary.

Access to the packaging area is preferably through dedicated chang-

ing rooms provided with hand hygiene facilities and lockers.

### **3. The Sterilization Area:**

The sterilizing area should contain the sterilizers and necessary accessories. The incubators for biological monitoring should also be placed in this area.

This is considered a “clean” area, therefore, contaminated transport trays or containers and sealed packages ready for sterilization should be transported from the packaging area directly to the interior of the sterilizer chambers without contacting any of the surfaces in this area.

Contaminated gloves, transport containers, and packages should not contact any countertop, table, wall, or other surface in this area. If the outer surface of a sterilizer becomes inadvertently contaminated, it must be disinfected immediately with an appropriate surface disinfectant.

### **4. The Storage Area:**

The storage area should be an environmentally controlled area which contains the closed storage cabinets, drawers, or slots in which the sterilized instruments are kept until needed. If possible, clean supplies and instruments should also be stored in closed or covered cabinets. Processed items should not be stored under sinks or near sharp edges or in other locations where they might become wet or torn (see Storage and Shelf-Life for details).

A hand-washing sink, a regular waste container, and a set of house-keeping cleaning items must be available in this area also.

## **CSSD Staffing and Attire [108]**

The staff put in charge of operating this department should be trained in the proper methods of cleaning of items, packaging, sterilization, process monitoring, and management of sterilized items such that a standardized quality of sterilization is provided for all the clinics. The CSSD should have a sufficient number of staff such that each step of the processing sequence may be performed by a designated staff member(s).

Personal protective attire must be worn by CSSD staff to protect against chemical and biological hazards. The following protective attire must be worn by staff in the respective areas of the CSSD (for specifications, see section on Personal Protective Equipment). Staff who are involved in the maintenance of decontamination equipment should be required to wear the same type of clothing.

### ***The Decontamination Area***

The protective attire to be worn by staff in this area should include well-fitting puncture-resistant, heavy-duty utility gloves to prevent inadvertent percutaneous injury or contact with chemicals; face mask and protective eyewear or face shield; a head cover, and a long-sleeved gown or jacket should be worn. Hair should be entirely covered by the head cover.

Shoes designated for use in this area should be considered as part of the protective attire and should be non-slip, enclosed footwear that are sufficiently robust to protect feet from injury or contact with sharp objects (e.g. if sharps are dropped accidentally). Shoes that are made from canvas or cloth material are unsuitable and should not be worn. Shoes worn in the decontamination area are considered part of the protective attire and should not be worn outside the work area. Or, alternatively, disposable shoe covers may be worn over street shoes when entering this area and removed when leaving.

### ***The Packaging Area***

Staff in this area must also wear a head cover, long-sleeved gown, well-fitting puncture-resistant utility gloves, face mask, and eye or face protection to protect against percutaneous or permucosal injury.

### ***The Sterilization Area***

Staff in this area need to wear gloves and a mask when transporting the processed trays and packages to the inside of the sterilizers. However, when monitoring the sterilizers and handling sterilized items, gloves should not be worn.

For all CSSD staff, protective attire should be changed daily or whenever it becomes visibly soiled or wet. Staff should never leave the CSSD or their respective work areas wearing the protective attire. All protective attire must be removed and hands washed before leaving the work area.

After removal, disposable attire should be discarded in the waste receptacles. Reusable attire should be placed within the dirty laundry receptacle in the changing rooms. The used attire should be sent for laundry every day.

### **Environmental Disinfection of the CSSD [108]**

Work surfaces (including sinks) must be cleaned and disinfected daily at the end of the workday, and whenever necessary, with an intermediate-level disinfectant using the spray-wipe-spray technique. Floors must be wiped with an appropriate low-level disinfectant at the end of the work day also (see Chemicals Used for Disinfection and Sterilization in Dentistry). The storage drawers and cabinets in the storage area should be cleaned weekly with a low-level disinfectant (see Chemicals Used for Disinfection and Sterilization In Dentistry). And each section should be thoroughly cleaned annually. Air vents and filters should be cleaned and serviced regularly.

Environmental cleaning procedures and schedules adopted must ensure that contamination from dirty areas does not contaminate the clean areas. Separate cleaning equipment should be used for the different areas of the CSSD, and the equipment should be regularly cleaned and maintained.

If spillage of contaminated solutions or material occurs, it must be cleaned as described in Management of Spills. If gross debris is present on the floor and washing is indicated, the flow of the washing solution should be from the cleanest area to the dirtiest (the floor drain should be in the area with the highest contamination risk). Housekeeping items used for cleaning one area should not be used for another area.

## Presterilization Cleaning

[2, 5, 10, 98, 100, 108, 116]

By definition, sterilization is a procedure to destroy all microorganisms- including viruses, bacteria, fungi, and spores.

According to their uses and potential risk for transmission of infection, instruments, devices, and equipment are classified as *critical*, *semi-critical*, or *non-critical*.

*Critical instruments* are surgical instruments and those instruments that penetrate soft tissue or bone (e.g. forceps, scalpels, bone chisels, scalers, burs). *Critical instruments* should be sterilized after each use.

*Semi-critical instruments* are those that do not penetrate soft tissues or bone but contact oral tissues (e.g. mirrors and amalgam condensers) or non-intact skin. *Semi-critical instruments*, also, should be sterilized after each use.

*Non-critical instruments* are those that contact only intact skin (e.g. external components of x-ray tubes). Such items may be disinfected between patients with a low-level disinfectant. If, however, the surface of the item is visibly soiled with patient material, then it must be disinfected with an intermediate-level disinfectant (i.e. one with a tuberculocidal claim). Pre-cleaning with a detergent before disinfection may be necessary depending on the type of disinfectant used (see Chemicals Used For Disinfection and Sterilization in Dentistry).

Cleaning or disinfection of certain non-critical patient-care items can be difficult or may cause damage to the surfaces; therefore, barriers should be used to protect these surfaces whenever possible.

Single use disposable instruments are not intended or designed to be cleaned, disinfected, or sterilized (e.g. some prophylaxis angles, cups, brushes, saliva ejector tips, and air-water syringe tips). Therefore they should be used once and discarded; they should not be “sterilized” or “disinfected” and reused.

Contaminated items must be properly prepared before they are sterilized to ensure the maximum benefit is obtained from the steriliza-

tion cycle. After being used, items must be adequately cleaned, rinsed, dried, properly packaged, and sealed before being placed in a sterilizer. New critical and semi-critical patient care items should also be sterilized before being used to treat patients for the first time.

Cleaning should remove all visible soil, dirt, dust or other foreign material. The presence of debris, especially if organic in nature, may compromise or interfere with the sterilization process. Therefore, instruments should be thoroughly cleaned of contamination prior to packaging and sterilization.

If contaminated items will not be cleaned immediately, they must be soaked in a holding solution, in a puncture-resistant container, to prevent drying out of the dirt and debris and to make cleaning easier and more effective. However, some plastic/resin cassette manufacturers do not recommend presoaking, so the manufacturer's instructions must be followed, and such items must be cleaned immediately to prevent drying out of the debris. Furthermore, extended presoaking for more than a few hours is not recommended because this may enhance corrosion of some instruments.

The holding solution used for presoaking should be a detergent, or an enzymatic cleaner, or a surfactant (a chemical which reduces the surface tension of surfaces of items increasing the wetting of the item by the surrounding solution). A disinfectant with no surfactant properties should not be used as a holding solution as some disinfectants coagulate proteins (found in patient debris) which makes cleaning more difficult as well as making it more difficult for the sterilizing agent to reach the embedded microorganisms. Use of solutions with fixative and toxic natures such as chemical sterilant/high-level disinfectants, for example gluteraldehyde, as a holding solution is not recommended.

During presoaking, loose instruments should be placed in a perforated basket in the holding solution in order to reduce direct handling of sharp instruments. The presoaked instruments and holding solution must be considered contaminated. The holding solution must be changed at least once a day (or earlier if visibly soiled).

During cleaning, care must be taken to minimize the amount of

splashing of contaminated solutions. After cleaning, adequate rinsing of the items to remove the cleaning solution before sterilization must be ensured as any chemical residue may damage the surface of items when they undergo the sterilization process. Rinsing and drying of items should not be performed with high-velocity water or air spray; such sprays lead to spatter and aerosolization and subsequent spread of microorganisms.

Contaminated items must be handled with caution to avoid percutaneous injury. DHCP should wear puncture-resistant, heavy-duty utility gloves when handling contaminated items. Because splashing is sometimes unavoidable, a mask, protective eyewear or face shield, and gown or jacket should also be worn. Operators should not reach into holding solutions holding sharp instruments that cannot be seen. Work-practice controls should include use of a strainer-type basket to hold instruments and forceps to remove the items. Also, used instruments should be transported in a rigid or puncture-resistant container.

Regardless of the cleaning process used, when cleaning and drying of the items is complete, all the cleaned items must be transferred to the packaging area immediately to avoid inadvertent confusion with the unclean items.

### **Cleaning Methods**

**[5, 10, 98, 105, 108]**

Cleaning may be done either by:

- a. use of an ultrasonic cleaner,
- b. use of a specially designed washing machine/ thermal disinfectant, or
- c. scrubbing with a detergent/surfactant and brush under running water.

Cleaning should be automated whenever possible, because automated cleaning is more validated, more easily controlled, more efficient, and decreases the risk of percutaneous injury and exposure of staff to potentially infective material. Washing machines are the preferred

method of cleaning instruments, but an ultrasonic cleaner should be used for pre-treatment of those items which are required to be cleaned by this method according to the manufacturers' instructions. Manual scrubbing of contaminated items with a brush is the least preferred method for cleaning of instruments. However, if necessary, manual cleaning may be used if the necessary precautions are taken, and only following pre-treatment in an automated cleaner.

### ***Ultrasonic Cleaning***

An ultrasonic cleaner should be provided for pre-treatment of those items which are required to be cleaned by this method according to the manufacturers' instructions.

Not all items are amenable to ultrasonic cleaning; plastics and other similar materials cannot be successfully processed by this method. Chrome-plated items should also not be placed in the unit because the mechanical vibrations can cause the plating to flake. Therefore items' manufacturer's instructions must be referred to in this regards. Furthermore, items made of different metals should not be combined in the ultrasonic cleaner in order to avoid ion transfer which may cause etching and pitting of the items.

During operation, the cleaner must be covered with its lid to prevent aerosolization of the contaminated contents into the workplace. Therefore, preferably, the ultrasonic cleaner should be fitted with a lid which is interlocked to prevent operation of the ultrasonic cleaner when the lid is open.

Solutions used with this type of cleaner should be cleaning or enzymatic solutions specified for ultrasonic use to ensure they possess the necessary surfactant property required for adequate cleaning of the instruments. Mere disinfectants are not sufficient if they do not have surfactant properties. Items should never be placed directly onto the base of an ultrasonic washer or contact the walls; they should be placed in an appropriate basket designed for the ultrasonic cleaner.

The ultrasonic cleaner should be operated according to the manufacturer's instructions.



It must be remembered that after ultrasonic cleaning, the instruments are still contaminated. Also, the cleaning solution will be contaminated with live microorganisms. Thus ultrasonic cleaners should be labeled with a biohazard label as well as a chemical label (because of the chemical solution).

The ultrasonic cleaner should be tested when first purchased and, afterwards periodically, to assure that it is operating properly. Testing should also be conducted whenever there is reason to suspect a deterioration in the cleaner performance (such as if longer times become necessary to remove soil, following repair, and following periods when the cleaner has not been in use). The manufacturer's recommended testing procedure should be followed. In the absence of manufacturer recommendations, the Foil Test should be used (see separate document on Infection Control Policy and Procedures).

### ***Washers-disinfectors***

#### ***Choice of Washer:***

Washing machines are the preferred method of cleaning instruments prior to sterilization. However, only washers-disinfectors cleared for use with medical devices should be used; household dishwashers should not be used. The washing machine should be a washer-disinfecter which runs a washing cycle with detergent followed by a thermal disinfection cycle and a drying cycle. All autoclavable patient care items may be safely processed with a washer-disinfecter.

#### ***Source Water:***

Source water for the washer should be compliant with the manufacturer's recommendations. Hard water should not be used with washers because deposition of lime-scale on the washer components impairs its performance. Furthermore, using hard water in the thermal disinfection and final rinse stages is one of the major causes of white powdery deposits on load items. These deposits act as a focus for soiling and recontamination of the item in use. In some applications (e.g. with optical systems) such deposits may seriously impair the utility of the item.

The temperature at which water is supplied to each stage of the

process has a major effect on the efficacy of the process. Water at too high a temperature during the initial flushing stage may lead to the coagulation of proteins and thus serve to “fix” proteinaceous soil to the surface of the load items. The initial flushing stage should be supplied with water from a cold supply so the temperature does not exceed 45°C. When enzymatic cleaners are used the water temperature must be maintained close to the optimum temperature specified by the manufacturer; too high a temperature will inactivate the enzymes.

Ionic contaminants in the water must be regulated because they may react with materials such as stainless steel. Therefore, the water supply used for washers should have a chloride concentration less than 120 mg/l Cl<sup>-</sup> to minimize the risk of corrosion. Heavy metal ions such as iron, manganese, magnesium, copper, or silicates present in the water may cause tarnishing of stainless steel items. Total dissolved solids should be checked with conductivity meter.

The microbial population in the water used in the washer-disinfector particularly in the final rinse stage of process cycle should not increase the bioburden of the load items. Water with < 100 cfu/ml is suitable for the final rinse stage. Bacterial endotoxins are not readily inactivated at the temperatures used for disinfection or sterilization. Therefore, when the washer is being used to process surgically invasive items, water used for the final stages of processing should not contain more than 0.25EU/ml.

### ***Operation of Washer:***

When placing items in a washing machine they should be placed in a manner which ensures effective cleaning; all surfaces should be exposed to the action of an automated cleaner. Overloaded baskets will result in ineffective cleaning, therefore items should not be bundled tightly together or placed one on top of the other.

When lumened devices (e.g. handpieces, high volume evacuators, stainless steel suction tips) are being washed, the washer/disinfector should be provided with load carriers that permit the irrigation of the lumen. Jointed items should be processed in the open position. Sharp items should be placed separately from other items in order to facilitate

ease of identification after cleaning and prevent sharps injury.

With single-ended washer-disinfectors (washers with only one door), care must be taken during insertion and removal of items to ensure adequate segregation of processed from unprocessed items.

If a washing cycle is aborted for any reason, the incident should be noted in a log book, along with the reason for termination of the cycle, and any corrective action taken.

### ***Manual Cleaning***

Manual scrubbing of contaminated items with a brush is the least preferred method for cleaning of instruments, and is strongly discouraged, because it increases the risk of injury to personnel by the contaminated items, and because of the amount of spatter and aerosolization that might result. However, if necessary (e.g. if cleaning devices failed to remove debris), hand scrubbing may be used if the necessary precautions are taken, and only following pre-treatment in an automated cleaner.

Scrubbing should be done with a detergent or surfactant, and water. When scrubbing items, heavy duty utility gloves should be worn, and a long handled brush used. To reduce the amount of spatter, scrubbing should be done near the base of a deep sink with the instruments soaked in a container and under running water.

In order to ensure consistent quality of manual cleaning, the variables that affect the manual cleaning process should be controlled as much as possible in the following way:

1. Staff training/competence. Staff must be trained in a systematic method of cleaning.
2. Water temperature. The temperature of the water used for manual cleaning should be optimum and consistent throughout the year.
3. Detergent concentration. The concentration of the detergent used must be optimal and consistent.
4. Nature of debris. Different types of debris require different pre-

soaking and scrubbing times. These times should be standardized for the different types of debris.

If either the cleaning solution or rinse water becomes visibly soiled or contaminated, it should be changed and the process repeated. After manual cleaning, the brushes, detergent container, and sink should be cleaned, disinfected, rinsed, and allowed to dry.

When drying the washed instruments, they should be allowed to air-dry or be carefully patted with thick towels. Instruments should not be rubbed or rolled in the towel as this increases the risk of accidental injury.

### **Drying and Lubrication [5, 108]**

After cleaning, items must be dried well before packaging because water on the surface of items may interfere with the sterilizing agent (e.g. steam or heat) reaching the items, or may cause tearing of the paper wrapping material. After drying, non-stainless steel instruments should be treated with a rust inhibitor.

A washer-disinfector with a drying cycle is the preferred method of drying. If items cannot be processed in the washer-disinfector, manual drying should be done using a clean disposable lint-free, absorbent wipe, taking care to prevent percutaneous injury. If manual drying is performed, items should be dried in a sloping position to facilitate drainage.

Before packaging, burs and other carbon steel instruments may be sprayed with a rust inhibitor or a small piece of gauze may be added into the pack to absorb the excess moisture during steam sterilization. Items which need to be lubricated prior to sterilization should be lubricated at this point. Excess lubricant, however, should be removed prior to packaging.

### **Preparation of Handpieces, Motors, and Couplings** **[10, 95-96, 98, 108, 111, 116, 158]**

New handpieces (including scalers) should be sterilized before being used for patient treatment for the first time. Also after treatment of

each patient, the handpiece must be heat sterilized in an autoclave. Studies have indicated that the inner surfaces of high-speed handpieces and prophy-angles may become contaminated with patient material during function. The only effective way of cleaning the lumen of a dental hand-piece is to process it through a washer-disinfector with each lumen connected to a flushing system.

Furthermore, restricted physical access to the internal surfaces of the handpiece limits sterilization with chemicals; therefore, handpieces must be heat sterilized between patients. Surface disinfection or immersion in high-level disinfectants is insufficient to adequately and safely process such devices.

When choosing the method of cleaning of handpieces or any device which enters the oral cavity, the instructions of the manufacturers of both the handpiece and the cleaning device must be adhered to. Failure to do so may result in failure of sterilization or damage to the handpiece or both.

### **Inspection [10, 108]**

After items are cleaned and dry, the used washer–disinfector and the processed items must all be inspected for validation of the cleaning process before the processed items are packaged. The area where inspection takes place should be designated and controlled to minimize contamination of the processed items.

#### ***Inspection of Washers-disinfectors***

A typical cycle comprises the following phases:

- a) cold rinse,
- b) warm wash,
- c) rinse,
- d) disinfection rinse, and
- d) drying.

On completion of the washing cycle, it must be ensured that all pro-

cessing stages and parameters have been achieved. The effectiveness of the washing-disinfection process cannot be verified by inspection or testing of the processed items only; it can only be guaranteed if correct conditions are created throughout the washer-disinfector chamber and the load during every cycle.

The chart record for the cycle should be checked to ensure that all recorded variables are within the parameters permitted and in accordance with the specification for the load used. The rotation of the arms should be checked. If arms do not rotate, loads should be rejected as the load has not been exposed to the water spray effectively.

All documentation for automated cleaning should contain the following information:

1. Washer-disinfector identification number.
2. Cycle number.
3. Type of washer-disinfector.
4. Type of cycle used.
5. Date and time of start of cycle.
6. Critical parameters for the specific washer disinfector cycle.
  - a. Temperature.
  - b. Time.
  - c. Enzymatic detergent concentration.
7. Results of washer-disinfector process (pass- fail).
8. Any notes or observation for the process cycle.
9. The identification and signature of responsible person confirming whether or not the process cycle was within recommended parameters.
10. Aborted cycles should be noted in a log book, along with the reason for termination of the cycle, and any corrective action taken.

## ***Inspection of Processed Items***

The processed items should be inspected to ensure they are dry, and there is no obvious damage, staining or residue. Any patient care item which needs maintenance or lubrication should be serviced at this stage.

If the load is damaged, this may be due to the configuration of the load, i.e. rotating arm may be hitting off the items being processed, or the items may not be compatible with automated washing. If staining and/or residue are present, this may be due to the configuration of the load, overloaded cart or malfunction in the washing cycle.

If a load is not properly cleaned, the entire load is rejected and returned for re-cleaning. Any load or items rejected as unclean should be documented as a non-conformance; this non conformance should also be documented into the washer-disinfector log book for further investigation by the relevant maintenance personnel.

### **Packaging**

**[5-6, 10, 82, 108, 116]**

Pre-sterilization packaging ensures sterility of the items is maintained until the package is opened. Therefore, instruments that will not be used immediately after sterilization should be wrapped or bagged before sterilization in a material recommended by the manufacturer of the sterilizer.

### ***Selection of Packaging Material***

Materials used for packaging should comply with European standards EN ISO 11607-1 and EN ISO 11607-2, 2006 and EN 868 parts 2-10, inclusive, or should be FDA- cleared.

The packaging material must be specified for the particular sterilization method used, and must allow the sterilization process to affect the contents of the sealed package while adequately maintaining their sterility during transport and storage. It must also facilitate the aseptic technique at all times, including opening of package. Suitable materials for packaging used with steam autoclaves include wrapped perfo-

rated instrument cassettes, peel pouches of plastic or paper, and paper wraps. Unsuitable materials for use with steam autoclaves are closed metal (unless proven otherwise by biological monitoring) or glass containers, thick cloth, and some plastic containers.

Packaging material used with steam autoclaves must be designed for such use , and must conform to the following :

1. Maintain integrity of the pack through the following:
  - a. Provide adequate seal integrity.
  - b. Provide an adequate barrier to particulate matter and fluids.
  - c. Be resistant to punctures, tears and other damage which may break the barrier and cause contamination
  - d. Resistant to penetration by micro-organisms from the surrounding environment.
  - e. Free of holes, tears, or flaws.
2. Be compatible with and able to withstand physical conditions of steam autoclaving.
3. Allow penetration and removal of steam.
4. Permit use of material compatible (i.e. non-degradable) with the sterilization process.
5. Be used according to the manufacturers' instructions.
6. Be free of toxic ingredients.
7. Low-linting (wrapping material).
8. Tamper proof and able to seal only once.

### ***Storage of Packaging Materials***

Packaging materials should be stored at a temperature of 18°C to 22°C and at a relative humidity of 35% to 70% in order to maintain the integrity of the product. They should be stored on shelves and not on the floor or adjacent to external walls or other surfaces which may be



at a lower temperature or a higher temperature than the ambient temperature of the store room.

The packaging material stock should be rotated to ensure it does not exceed its shelf life.

### ***Process of Packaging***

Items may be packaged in functional sets or individually, according to their uses. Packing of items individually (e.g. handpieces) is recommended whenever practical in order to avoid repeated sterilization of unused items. Burs are best packed individually to prevent contamination of large numbers of burs once a container is opened. To minimize corrosion, they may be sprayed with a rust inhibitor or a small piece of gauze may be added into the pack to absorb the excess moisture. Endodontic files may be sterilized in unit sets, again with gauze, to avoid contaminating the entire contents of an endo box once it is opened. Hinged instruments should be processed open and unlocked. All examination sets should have a folded thick paper lining included within the package in order to be used as a sterile lining to be placed under the instruments.

Single use packages should be used once only then discarded. And when double wrapping items using paper/plastic pouches, the paper portions should be placed together to ensure penetration and removal of steam and air, and to allow visibility of the inner contents.

If items are to be used immediately after the sterilization cycle, they may be sterilized unwrapped provided they are handled after sterilization aseptically by sterile instruments and transported to the point of use in a covered sterile container. Such items should not be stored for longer than one work session; after the session they are no longer considered sterile.

If sharps containers or biohazardous waste containers containing regulated waste are to be sterilized before disposal, they should be left open during sterilization to allow for penetration of the sterilizing agent. Sealing may be performed after the end of the cycle. It must be noted, however, that not all sharps and biohazardous waste containers can

withstand the high sterilization temperatures.

When packaging items, each package must have an external and internal chemical indicator. Chemical indicators are substances, which change color when they are exposed to temperature, moisture, and time conditions necessary for sterilization. Chemical indicators should be compatible with the packaging material. The type used should be designed for use with steam autoclaves. The indicator should be stored and used following the indicator manufacturer's instructions. The use of an inappropriate indicator may give dangerously misleading results; indicator performance can be adversely affected by the storage conditions and methods of use. Indicators should not be used beyond their expiry date.

External chemical indicators should be present on the outer surface of packages and are also called ***process indicators or rapid-change indicators***. Internal chemical indicators are placed with the items to be sterilized within the packs and are also called ***integrating indicators or slow-change indicators***.

External indicators, e.g. autoclave tape and special markings on commercially available packages, change color rapidly after a certain temperature has been reached. They should be used as external indicators applied to the outside of each instrument package to verify that the package has been exposed to the sterilization process. However, because they change color very soon after exposure to a high temperature, these indicators should not be considered a reliable indicator that sterility has been achieved

Internal indicators should be of the slow-change type, which are multi-parameter indicators designed to react to two or more sterilizing parameters and are a more reliable indicator that sterilization conditions have been met. They should be used as internal chemical indicators placed inside every single instrument pack to ensure the steam has penetrated the packaging material and actually reached the instruments inside. If an internal indicator is visible from the outside, an external indicator is not necessary.

Although chemical indicators may indicate that the necessary steril-

ization parameters have been reached, they should not be considered as an assurance of sterility because they cannot guarantee that the packages have been exposed to the necessary parameters for the required time. However, they may be useful to identify instrument packs that have been processed through the heat cycle. Since their results are received when the sterilization cycle is complete, they are useful in early identification of gross malfunctions in the sterilizing unit and failures in packaging and loading. Thus they should be used with each and every instrument pack entering the sterilizer.

Written and illustrated procedures for preparation of items to be packaged should be readily available and used by personnel when packaging procedures are performed.

### ***Sealing Packages***

The purpose of sealing is to provide an air-tight seal and maintain pack integrity, this can be achieved by the use of heat sealers or sterilizing chemical indicator tape. Heat sealing is preferred because it is more reliable, but if heat sealing is not possible, triple folding and sealing with indicator tape is an acceptable alternative. The indicator tape, however, must be specific for use with steam autoclaves and change color when exposed to autoclave parameters.

Self-sealing packs should not be used due to the difficulty of achieving an air-tight seal at the edges of the pack. Pins, staples, or paper clips are unacceptable for “sealing” because they leave unsealed holes which may allow for entry of microorganisms. Tape not designed for use with autoclaves should not be used.

For heat-sealing pouches, the melting point of the heat-seal will effectively limit the maximum temperature at which the pack can be used. Therefore, only heat-seal packaging which may be used at temperatures achieved by steam autoclaves, as specified by the manufacturer, should be used. Heat seal pouches should be sealed using suitable heat sealing equipment, and should provide a seal of proven integrity and not allow resealing.

## ***Process of Heat Sealing***

As much air as possible should be removed from the pouches before sealing because air acts as a barrier to heat and moisture. Furthermore, expansion of air during the sterilization process may cause the bag to rupture during the sterilization process.

When the open end of pouch is placed in the heat sealer, and the heat and pressure are applied to the surface of the pouch, it must be ensured that there are no creases in the packaging material. Creases can result in inadequate or uneven seal.

Adequacy of the seal must be checked, especially near the corners. In some types of pouches, weak spots of the seal are where the paper is folded back on itself or where four thicknesses of material become two. To minimize failure of sealing, the minimum number of thickness of packaging material should be sealed together.

When double wrapping pouches, the outer package should be larger than the inner, so as to avoid folding the inner package while attempting to fit it into the outer package. Folding the inner pouch should be avoided because it may entrap air and inhibit sterilization.

If indicator tape is used to seal pouches, the corners at the open end of the pouch should be folded diagonally, then the top of the pouch folded over three times. The tape should then be used to fix the fold in position, and must extend along the full length of the fold.

After sealing the pouches, they must be inspected to ensure adequacy of the seal, in addition to absence of tears, flaws, or holes, before transfer to sterilizers.

## ***Monitoring of Heat Sealing***

Routine monitoring of processed heat sealed products should be undertaken by checking the quality of the output. Heat seal efficiency, integrity and strength test should be performed as recommended by the manufacturer on each heat sealer daily.

Heat sealers should be serviced yearly. This service includes temperature calibration and heat seal integrity and strength of seal.

## Sterilization Process

[2, 5-6, 10, 82, 100, 105, 108, 111, 116, 159]

Whenever possible, only those critical items which may be sterilized with steam should be used. For critical and semi-critical items, if heat-stable alternatives are not available, then heat-sensitive objects can be treated with hydrogen peroxide gas plasma sterilizers; or if gas plasma is unavailable, by liquid chemical sterilants. The use of heat-stable items is preferred because the process of steam sterilization has the largest margin of safety due to its reliability, consistency, and lethality.

Critical and semi-critical dental instruments that are heat stable should be sterilized between uses by steam autoclaving following the instructions of the manufacturers of the instruments and the sterilizers. Only autoclaves with a prevacuum and post-sterilization vacuum and drying cycle should be used. Downward displacement (gravity displacement) sterilizers are not appropriate for sterilizing wrapped loads or for items that contain a lumen (e.g. handpieces, high volume evacuators, stainless steel suction tips), and should not be used for these purposes under any circumstances. Flash sterilizers rely on natural air displacement and should not be used for wrapped goods, hollow devices (e.g. handpieces) or tubing. Boiling water sterilizers, hot air ovens, ultra violet light treatment, hot bead sterilizers and chemiclaves are not appropriate for sterilizing dental items and should not be used.

When acquired, autoclaves should be subject to planned preventative maintenance through a comprehensive service plan, the equipment should only be operated by trained and competent personnel.

### ***Loading of Autoclave Chambers***

The manufacturer's recommendations for loading the sterilizer must be followed. Packages to be sterilized should be placed in the chamber in a way that allows free circulation of the steam. Overfilling of the autoclave chamber should be avoided. Packages should be placed in perforated or mesh bottom racks or baskets and should not contact the chamber floor or walls, and should be loaded such that an air space of a few centimeters is formed between each layer of packages.

Packages should be separated from each other; they should be placed on edge and not be stacked flat in layers. When loading paper/plastic pouches into the sterilizer the packages should be placed in the same direction, (i.e. paper/plastic, paper/plastic). Plastic surfaces should not be placed facing each other because plastic impedes the movement of the steam into and out of the package. Folded drapes packs should also be loaded with the wrapping layers vertical, allowing air to be removed for the drape pack rapidly.

Handpieces should be placed in the center or upper shelf of the autoclave chamber because the temperature at the bottom of the chamber may rise above the set value.

Items with a lumen (e.g. handpieces, high volume evacuators, stainless steel suction tips) should be placed upside-down or tilted, to prevent collection of condensed steam. Heavy packages should be placed below lighter ones to avoid the condensate wetting the light packages. If using autoclaves without a post-sterilization drying cycle, sterilized packs should be allowed to dry inside the sterilizer before removing and handling because wet instrument packages are not considered an acceptable barrier against recontamination.

### ***Operation of Autoclave***

Autoclaves must be operated with strict adherence to the manufacturers' instructions. Before operating the device, it must be ensured that the cycle recorder(s) has sufficient paper and ink to record the cycle. A Steam Penetration test (e.g. Bowie-Dick Test) must be carried out daily at the beginning of the workday to ensure that the pre-sterilization vacuum is functioning properly leaving no residual air pockets in the chamber. If an autoclave fails the air removal test during commissioning or during routine (daily) testing, it should not be used until inspected by the appropriate maintenance personnel and it passes the test. The Bowie Dick test must also be repeated after maintenance of sterilizers.

After verification of proper function of the pre-sterilization vacuum, the autoclave may be used to process instruments. The correct operating cycle for sterilization must then be selected (Note: test cycles such as a Bowie and Dick test and leak rate test cannot be used for

sterilization) .

Maximum efficiency of the autoclave can only be achieved if suitable conditions are present in the chamber. The sterilization hold period should be at 134-137°C for not less than 3 minutes or 121-124°C for not less than 15 minutes . However the temperature of the chamber, even during the drying phase, should not exceed 135°C if handpieces are being autoclaved, and should not exceed 140°C if ultrasonic scaler handpieces or air-water syringe components are being autoclaved . The manufacturer's instructions of sterilizable items regarding temperature of sterilization must be adhered to.

The doors of autoclaves should be open only when loading and unloading. An open door will cause the chamber to cool down and may cause condensation during the subsequent process .

The following are some conditions which may compromise optimum sterility, and thus must be monitored and avoided:

- a. Faulty preparation of materials for sterilization (packaging that does not allow for steam penetration).
- b. Improper loading of unit chamber. Overloading or placement of excessively large packages at the top of the chamber can prevent the flow of steam from the top of the chamber to the bottom.
- c. Sterilizer malfunction (failure to reach temperature and/or pressure).
- d. The presence of air in the chamber, which may delay microbial destruction up to 10 times longer.
- e. Excess water in the steam, which can serve as a passageway for microorganisms to penetrate wet instrument packages.

At the end of the sterilization cycle, items, especially handpieces, should be removed from the autoclave chamber immediately. Care must be taken to ensure the packages are dry before handling and storage .

## **Verification of Sterilization Cycle**

Before the processed packages are labeled as sterilized and released for use, each sterilization cycle must be verified as satisfactory in the following way:

1. **The records obtained from the cycle recorders must be examined** to confirm that the cycle variables were within the limits established as satisfactory by the manufacturer. The variables which need to be examined include:
  - a. The number and extent of air removal pulses.
  - b. The temperature and duration of the sterilization plateau period.
  - c. The depth and duration of the drying vacuum.

Whenever possible, the data should be read from the independent recorder not from the automatic controller record.

Correct time, temperature, and pressure readings do not guarantee that sterilization has taken place but incorrect readings do indicate a problem within the cycle . Failure of a test implies that the sterilizer is not working to specification .

Any cycle not meeting the criteria, although indicated as a pass by the automatic controller, should be rejected. The load processed during that cycle should be considered not sterile, and the autoclave removed from service until the cause of the fault has been identified and corrected. A failure of the cycle recording device should also be a cause to reject the sterilization cycle, and the autoclave should only be used if the recording device is functioning properly.

2. **The packaging should also be examined to ensure it is intact** (i.e. seals, taped joints have not come undone, packs are not torn) and completely dry and free from visible dampness. Any labels, if present, should also be intact and legible.
3. **The chemical process indicators should be inspected** to ensure they have changed color as described in the indicator manufacturers' instructions (see Section Process of Packaging).



4. **The biological monitoring test (spore test) result should be obtained** indicating there is no bacterial growth. Even if mechanical monitoring and chemical indicators indicate that sterilization conditions have been reached, biologic monitoring (spore testing) remains the most reliable technique for evaluation of whether or not sterilization is taking place.

Biologic indicators (BIs) come in the form of a paper strip impregnated with bacterial spores and placed in glassine envelopes or a glass vial containing a spore suspension embedded in culture media in a plastic vial. BIs designed for use with steam autoclaves contain *Bacillus stearothermophilus* spores. BIs designed and indicated for a particular type of sterilizer are not necessarily appropriate for another type of sterilizer. However, **dual-species biologic indicators** contain two types of spores and may be used to test several types of sterilizers, including steam autoclaves. Thus, the biologic indicator's manufacturer's instructions must be followed.

### ***Procedure for Spore Test***

Biologic indicators (BIs) should be placed in a typical load for the sterilizer being tested. The BI should be placed in each type package used and should be placed in the most difficult area for sterilization to occur; it should never run in a separate load by itself. Afterwards, the test specimen should be incubated in an incubator appropriate to the test container.

After incubation, the test specimen should have no viable organisms present. A control specimen from the same batch of vials, should be incubated along with the test specimen to ensure the incubation conditions are correct. The control specimen should yield growth of viable microorganisms. Records should be kept for each autoclave indicating the date and result of the spore test.

*Action to be taken in the event of a positive spore test (sterilization failure):*

If the spore test is positive (i.e. spores are still alive at the end of the sterilization cycle), definitive action must be taken. **The Infection**

**Control Officer must be notified**, and a tag or sign must be placed on the unit to prevent its use and all items sterilized in the same unit since the last negative test must be recalled and re-sterilized in another unit (see Labeling of Packages). A second spore test must be run through the same unit to verify the first result. If the result is positive again, the following must be investigated:

1. Determine the reliability of the BIs.
  - a. Were the proper BIs used for the particular sterilizer?
  - b. Were the BIs stored properly before use?
  - c. Were the BIs used before the expiry date?
  - d. Were the BIs handled properly before and after processing through the sterilizer?
  - e. Were the BIs incubated for the correct time at the correct temperature?
  - f. Was the positive spore test confirmed by bacteriologic means? (growth from positive BIs should yield gram-positive bacilli when smeared on a glass slide and viewed under the microscope at a magnification of 1000x).

If the BIs were found to be reliable and a true failure of sterilization has taken place, then the next step must be performed.

2. Take the autoclave out of service.
3. Review loading and operator procedures and determine if they were properly performed by the staff.
  - a. Were there any changes in packaging or loading procedures?
  - b. Was sufficient steam available?
  - c. Were time and temperature readings correct?
  - d. Was there anything different about the cycle?
  - e. Was a new staff person involved with the instrument pro-

cessing?

If problems are detected at this stage, the necessary corrections must be made then the unit retested.

4. Retest and observe the cycle.

The sterilizer should be retested with another spore test using the same cycle and approximate load that yielded the sterilization failure. Sterilizer technical parameters must all be noted to determine if they indicate proper sterilizing conditions.

If the spore test is still positive, then the sterilizer must be put out of service, and its power cord must be unplugged to ensure it is not used until after servicing and repair. After repair, proper function must be determined by biologic testing before the unit is used to process items.

### ***Timing of Biological Monitors***

Biological tests must be done weekly on steam sterilizers to verify proper use and functioning. **If a sterilizer is used frequently (e.g., several loads per day), biological tests should be done daily.** They should also be performed:

1. Before use of a new sterilizer unit (for installation testing, three consecutive cycles should be run with a biological indicator test pack.
2. If the unit has been serviced, disconnected, or moved.
3. When a unit has been unused for some time.
4. Whenever a new type of packaging material or tray is used.
5. During and after training of new sterilization staff.
6. After any change in sterilizer-loading procedure.
7. When new sterilizer parameters are being used.
8. If implants are to be sterilized. A spore test should also be done for every sterilizer load that contains an implantable device and the implant withheld until results of the spore test are known.

## ***Causes of Sterilization Failure***

Failure of sterilization may occur due to unit malfunction or operator errors. Care must be taken to avoid the frequent operational problems which may diminish the effectiveness of a sterilizer, and which *include*:

1. Improper cleaning of instruments.  
Presence of debris may insulate microorganisms from direct contact with the sterilizing agent.
2. Improper wrapping of instruments.
  - a. Closed containers may not allow penetration of steam or chemical vapor.
  - b. Some packaging materials can not withstand high temperatures.
  - c. Excessive packaging material may retard penetration of the sterilizing agent.
3. Improper loading of the sterilizer.
  - a. Overloading increases the heat-up time and retards penetration of the steam to the center of the sterilizer load.
  - b. Lack of separation between packages even without overloading may prevent the steam from reaching all items.
4. Error in timing the cycle (sterilizer timer malfunction).
5. Sterilizer malfunction.
6. Improper method of sterilization.

Processing heat-sensitive items with high temperatures will cause them to melt or deform.

Thus, to reduce the chances or risk that a non-sterile item exists in a sterilized load, the following must be ensured :

1. Use of quality sterilization equipment and following manufacturer's maintenance recommendations.

2. Operation of sterilizer correctly.
3. Training of sterilizer operators.
4. Monitoring the effectiveness of sterilization procedures routinely.

### ***Sterilization Cycle Records***

For each sterilization cycle, the following information must be documented:

1. Sterilizer identification.
2. Cycle (batch) number.
3. Name of the loading operator and unloading operator.
4. Type of cycle used.
5. Date and time of start of cycle.
6. Contents of the load.
7. Chart record and/or print-out from sterilizer cycle.
8. Read out results of chemical and biological indicator test.
9. Signature of identified responsible person, confirming whether or not the process cycle was within recommended parameters and authorizing release or rejection of load contents.
10. Any notes or observation for the process cycle, including cycles which were aborted, with the causes and corrective action taken in a log book.

### ***Flash Sterilization***

Flash sterilization is a method of heat sterilizing unwrapped patient-care items for immediate use. Flash cycles were originally designed for emergency use such as when an instrument is in short supply and is dropped on the floor during patient treatment and needs to be immediately sterilized for continued use. With flash cycles, the sterilization time is reduced considerably, thus reducing the “safety factor” of microbial killing.

Items may be very hot at the end of a flash cycle, therefore care must be taken during handling and transport, and items must be allowed to cool before use. When flash cycles are utilized in steam autoclaves, dryness of the items must be ensured before handling them.

Furthermore, items are sterilized unwrapped, therefore they should be handled with sterile gloves or forceps and transferred immediately to the actual point of use by a covered sterile container. Instruments should not be stored unwrapped.

Mechanical monitors must be checked and chemical indicators used for each flash cycle. Because all implantable devices which have been sterilized must not be used until the results of biological monitoring of their load are known, unwrapped or flash sterilization of implantable items should not be performed (see Sterilization Monitoring).

Due to the reduction in the safety factor of microbial killing and hazards of storing unwrapped items, flash sterilization of items should not be used routinely as a substitute for purchasing additional instruments or simply to reduce instrument processing time.

### **Chemical Sterilization**

Liquid chemical germicides classified as high-level disinfectants/sterilants may, under certain conditions, destroy all microorganisms, including spores. If used to sterilize patient-care items, the items must be cleaned well and totally immersed in the solution. The manufacturer's instructions must be adhered to closely regarding the necessary contact time of immersion. Liquid chemical sterilants reliably produce sterility only if cleaning precedes treatment (because bioburden on the items interferes with the sterilization process ) and if proper guidelines are followed regarding concentration, contact time, temperature, and pH. After immersion for the appropriate contact time, adequate rinsing of immersed items with sterile water is required to remove all residue of the chemical. Furthermore, items must also be handled using sterile gloves, dried with sterile towels, and placed within sterile containers, and delivered to the point of use in an aseptic manner. If the processed item is stored before use, it should not be considered sterile and should be sterilized again just before use.

Sporicidal chemicals, however, are highly toxic; and glutaraldehydes have been associated with dermatologic irritation, eye irritation, respiratory effects, and skin sensitization. Thus, containers of such chemicals must be placed in well-ventilated areas and be covered at all times.

These solutions lose their potency and effectiveness over time so chemical test strips or liquid chemical monitors are available for determining whether an effective concentration of glutaraldehyde is present despite repeated use and dilution. The frequency of testing should be based on how frequently the solutions are used (e.g., used daily, test daily; used weekly, test before use; used 30 times per day, test each 10th use), but the strips should not be used to extend the use life beyond the expiration date. Data suggest the chemicals in the test strip deteriorate with time and a manufacturer's expiration date should be placed on the bottles. The bottle of test strips should be dated when opened and used for the period of time indicated on the bottle (e.g., 120 days). The results of test strip monitoring should be documented. The test strip manufacturer's recommendations should be adhered to, including any recommended quality-control procedures. The chemical sterilant's concentration should be considered unacceptable or unsafe when the test indicates a dilution below the product's minimum effective concentration (MEC) (generally to <1.0%–1.5% glutaraldehyde) by the indicator not changing color.

The sterilization process with liquid chemical sterilants cannot be verified with biological indicators. For this reason, as well as the solutions' toxicity and difficulty of actually maintaining the sterility of the processed items after they are removed from the solution, the use of high-level disinfectants/sterilants to sterilize patient-care items is highly discouraged and should only be used if all the following criteria are met:

1. Item is not heat-tolerant.
2. There are no autoclavable options to replace the item.
3. The item is not a critical patient-care item (i.e. not intended to penetrate tissues).
4. In the absence of other safer sterilization techniques.

## Labeling of Packages

All packs subjected to a sterilization cycle should be labeled after they are sterilized to indicate:

1. The sterilizer in which the pack was sterilized,
2. The date on which the package was sterilized, and
3. The numerical sequence of the particular load on that day (i.e. first, second, third load, etc...).

Packages should never be labeled before they are sterilized so as to avoid confusion whether or not they have been sterilized. Labeling is important to help determine when and where a particular package was sterilized; such that in the event of a malfunction of a sterilizer, all packages processed in that unit after the last negative spore test may be recalled.

Label information should be documented on sterilization indicator tape or sticker label and not on the paper side of the packing material. Plastic/paper pouches can be labeled on the plastic portion. Marking pen or ink used to label the pack should be indelible, nonbleeding, and nontoxic. Sharp tipped water based or ball type pens should not be used as these may compromise the integrity of the pack.

If package contents are not visible through the packaging material, then a label (using sterilization indicator tape or sticker label) which identifies the package contents may be fixed to the surface of the packaging material. The label should be able to withstand exposure to the sterilization process. However, labeling with sterilizing information (referred to above) must only be performed after sterilization.

## Storage, Shelf Life, and Transport of Packages

[10, 82, 98, 105, 108, 120]

### **Storage**

All decontaminated and sterilized items must be stored in such a way that their integrity and decontaminated state is maintained. Improper storage of sterilized instruments may lead to their contamination,



therefore packages should be stored in a clean, dry environment and protected from sharp objects that may puncture or tear the packaging.

Packages should be stored in closed or covered cabinets. The amount of storage space should afford adequate room to store the package supply. Shelving should be easily cleaned and maintained and should enable items to be clearly labeled. Care must be taken that the storage area is not exposed to moisture, so the packages should not to be stored next to or under sinks, under water or sewer pipes, or in any location where they can become wet. Sterile items that become wet are considered contaminated because moisture contamination of the packaging material allows microorganisms to penetrate the material barrier.

Sterile materials should be stored on appropriate designated shelving at least 20-25 cm from the floor, 12cm from the ceiling (45 cm away from sprinkler heads), and 5 cm from outside walls. Items should be positioned so that packaging is not crushed, bent, compressed, or punctured and so that their sterility and integrity is not otherwise compromised. Compression of packages can force air and microorganisms into the package contents, cause seals to burst, or puncture the packaging, all of which lead to contamination.

Inspection of wrapper integrity should be performed before issuance of packages. Any wet, soiled, torn or open package should have its contents removed and re-sterilized. Packages which fall on the floor should also have their contents re-sterilized.

Use of the instrument packs should be on a first-in/first-out basis, i.e. the freshly sterilized packages are placed at the back so the previously sterilized packages are used first. This ensures proper circulation of packs as well as increases the time period between sterilization and use. This is beneficial in cases of positive spore test of an autoclave, because it increases the chances of recalling unused items sterilized in the defective sterilizer.

### ***Shelf-life***

Shelf- life of sterilized items should be event-related. This means that if the expiration date has not been exceeded, the contents of steril-

ized packages stored in the appropriate storage conditions (as stated above) may be considered sterile until some event causes the items to become contaminated. Examples of such events are a tear in packaging, packaging becomes wet, presence of insects or vermin in the storage space, or the seal is interrupted. Increased handling may lead to contamination of items.

Items not packaged but kept in strictly sterile, environmentally controlled areas can be considered sterile for that work shift only. After one work shift, the items may be considered “clean” but not “sterile”. Critical or semi-critical items must be packaged before sterilization if they will not be used immediately. Items removed from packaging but not used must be reprocessed.

### ***Transport***

Sterilized packages should be allowed to cool down before they are transported. Transport of items from the CSSD to the clinics or other departments should be within closed solid walled containers, or in covered or enclosed carts with solid-bottom shelves to protect them from exposure to environmental contaminants along the transportation route.

## **Maintenance of CSSD Devices [108]**

Validation, maintenance, and record keeping are necessary to demonstrate that equipment are functioning properly and that they will perform their intended function consistently.

### ***Validation***

Validation is the documented procedure for obtaining, recording and interpreting the results of different CSSD device operational records needed to show that a process is yielding a product complying with pre-determined specifications. It is considered as a process which comprises:

1. Commissioning (installation qualification and operational qualification).
2. Performance qualification.

3. Periodic testing.
4. Annual and revalidation tests.

### ***Commissioning***

This is the process of obtaining and documenting evidence that the equipment has been supplied and installed in accordance with its specifications by the supplier, that it is safe to operate (installation qualification) and that it functions within predetermined limits when operated in accordance with the manufacturer's operating instructions (operational qualification).

Installation qualification includes verification of calibration, automatic control test, water quality tests, water supply temperature, water supply pressure.

Operational Qualification tests should be carried out when:

1. a new device is purchased before it is used for the first time,
2. when a used device has been relocated to another premises, or
3. following critical repairs.

Installation and commissioning checks and tests should be performed by a person with specialist technical training. Data from the commissioning tests provide assurance that device function efficacy conditions are attained, i.e. the device is functioning correctly.

Even though the manufacturer should have tested a device before it left the factory, there is no guarantee that it will function correctly following delivery. Therefore, it should be tested before use to ensure that it is working correctly.

### ***Performance Qualification***

Performance qualification is required to show that function/efficacy conditions are attained even for loads and test loads that are assessed by the user to be difficult to process. Performance qualification is indicated for initial use of a new/relocated device or when the load profile changes (e.g. new type of items for processing). It should be carried

out by a suitably qualified person.

### ***Periodic Testing***

After validation, and when a device has been passed for use, it should be subject to a schedule of periodic tests at daily, weekly, quarterly and yearly intervals. The daily, weekly and quarterly tests should supply evidence whether or not the device is still operating within the limits established during commissioning.

### ***Annual and Revalidation Tests***

Annual tests (revalidation procedure) prove that the data collected during commissioning and performance qualification are still valid. Revalidation may also be required under certain circumstances.

### ***Preventive Maintenance***

A preventative maintenance schedule for all CSSD equipment and utilities should be planned for periodic, annual, and revalidation testing as recommended by the manufacturers' instructions for the various devices used in the CSSD. Whenever a new device is acquired, its maintenance schedule must be incorporated into the overall preventive maintenance schedule of the CSSD. The documented plan of maintenance tasks and the frequency at which they are carried out should be clearly specified.

Maintenance tasks should be performed as recommended by the manufacturers' instructions, and documented by qualified personnel. The CSSD devices should not be used to process contaminated items until all maintenance tasks have been completed satisfactorily and recorded.

Re-evaluation of function is also required after equipment relocation, engineering work, repair work, and software control function modifications.

A qualified staff member should review the maintenance plan and procedures and maintenance records periodically.

## ***Record Keeping***

A permanent record should be kept for each device within the CSSD to provide evidence that it was/is functioning correctly and achieving its intended results consistently. The record should include records of:

1. Commissioning and validation tests and checks.
2. A master process record (see below) should be provided by the company that installed the sterilizer.
3. Routine monitoring of every operational cycle. (See Sterilization Process- Sterilization Cycle Records)
4. Actions taken to correct any cycle failure and details of what happened to the unsatisfactory load.
5. Results of all periodic testing: daily, weekly, quarterly and annual tests.
6. Maintenance, repair, or any modifications.
7. Operator training records, which should include name of trainee, name of trainer, date of competency achieved in parameters as detailed in the staff training section.

### ***The Master Process Record***

The master process record contains the information gathered during commissioning by the manufacturer. It includes details of the values and permitted tolerances of the cycle variables for each correctly functioning operating cycle, and for each load type that is to be processed.

This is the record against which the following results should be compared:

1. Production cycle records: to verify that cycle conditions have been achieved for each load.
2. Results of weekly tests: to establish whether the device is functioning correctly and achieving the intended results.
3. Results of periodic tests and performance re-qualification tests.

## **ACQUISITION OF DEVICES AND MATERIALS**

Sufficient dental patient care items and accessories should be acquired to allow adequate time for reprocessing without adversely affecting the rate of patient flow. Items and materials should be assessed and considered for possible usefulness. A standardized screening and evaluation program may be implemented to assess such devices. [108, 113]

### **Screening of Devices and Materials**

**[108, 113]**

When they are available on the market, new designs of patient care items and safety devices should be screened by decision-makers and potential users. Screening assists in making decisions about clinical and safety considerations before evaluating a dental device in the clinical setting. Screening usually consists of physically examining the “safer” device, then comparing it to the traditional device and established evaluation criteria (see Appendix A: Sample Device Screening Form). Screening evaluation will help determine if the device is safe to use on patients, has safety features to protect dental personnel from sharps injury, is readily available for purchase, is easy and practical to use, and is compatible with other equipment.

No new device should be used on a patient before it has been screened to ensure that it meets clinical and patient safety needs.

### **Evaluation of Devices and Materials**

**[108, 113]**

After the device has been screened by the decision makers and some end-users, it should be evaluated for efficacy. Device evaluation involves a trial by the end-users of the device (we should specify how many) to determine the acceptability of a new design or “safer” dental device in an actual clinical setting. This process includes identifying the device to test, selecting the area of the facility to be used as the test site, selecting the staff (end users of the device) who will test the device, selecting evaluation criteria (see Appendix B: Sample Device Evaluation Form), and determining how long the test will last. The tra-

ditional device should be immediately available for use if the new dental device is found to be unsafe or unpractical. The evaluation should provide decision-makers with enough information to make an informed decision on whether to continue using the safety device.

### **Devices of Central Sterilization and Supply Department**

#### **[108]**

Acquisition, replacement, or upgrading equipment of the CSSD should be performed in accordance to needs of the level of service expected from the department, and should be compatible with existing items which need to be serviced. It should also be in accordance to, and compatible with, the existing or modifiable infrastructure of the building. As such any plan for acquisition, replacement, or upgrading equipment should be reviewed by a panel of relevant specialists.

## MANAGEMENT OF MEDICAL WASTE

[13, 90, 160-163]

Waste items contaminated with body fluids and tissues harbor human pathogens and considered one of the major potential sources of infection. Many human pathogens can be found in health care waste items, e.g. staphylococcus sp., HIV, hepatitis B and C in blood; salmonella, shigella sp. in feces and vomit; and streptococcus sp. in pus. The transmission routes for these infection sources from waste to a patient or health care worker are still uncertain. Only puncture injuries from sharps have demonstrated a clear infection pathway. For other waste items, if not by direct contact, the potential pathways are presumed to be airborne (e.g. spores or aerosols) or vectorborne (e.g. flies) transmission.

The safe and sustainable management of health-care waste is a public health imperative and a responsibility of all. Improper management of health-care waste poses a significant risk to patients, health-care workers, the community and the environment. Health-care waste can cause serious harm if not managed properly. For example, in 2000, WHO estimated that injections with contaminated syringes caused 21 million hepatitis B virus (HBV) infections (32% of all new infections), two million hepatitis C virus (HCV) infections (40% of all new infections) and 260 000 HIV infections (5% of all new infections). In addition, health-care activities generate significant amounts of hazardous waste such as mercury and expired pharmaceuticals.

The management of health-care waste is an integral part of a national health-care system. A holistic approach to health-care waste management should include a clear delineation of responsibilities, occupational health and safety programs, waste minimization and segregation, and the development and adoption of safe and environmentally-sound technologies. The right investment of resources and commitment will result in a substantive reduction of disease burden and corresponding savings in health expenditures.

The healthcare waste producer has a duty of care to ensure all healthcare waste is managed and disposed of properly in accordance



with the current waste regulations.

The primary message in waste management strategies should take into consideration:

1. Protecting the environment from pollution by hazardous effluents.
2. Minimizing the production, and reducing environmental impact of waste by reviewing materials used and practices employed.
3. Ensure that hazardous and nonhazardous dental health-care wastes are properly and efficiently segregated, packed, handled, stored, transported and disposed.
4. Ensure that policies and procedures for waste management are established, adopted, understood and implemented.
5. Provide information, instruction, training and supervision as necessary to ensure the implementation of waste management policy.

The healthcare waste policy should identify which member(s) of the staff are responsible for overseeing the local management of health-care waste including:

1. Identifying each waste stream as hazardous, or non-hazardous (segregation).
2. Handling and on-site storing of the healthcare waste.
3. Arranging for waste collection.
4. Record keeping.

### **Definitions [77]**

#### ***Generator:***

Any legal individual or body, such as health care facilities and their various departments, whose activity leads to generating healthcare waste.

#### ***Waste Segregation:***

This is the separation of the different groups of healthcare waste,

performed by the generator at the site of waste generation in the facility, and during the stages of collection, storage, and transportation within the facility.

***Transporter/Carrier:***

The legal individual or body (company, public/private establishment) working in the field of hazardous healthcare waste transportation to a waste treatment and disposal facility.

***Waste Treatment and Disposal Facilities:***

These are the facilities in which the operations of changing biological, chemical, or physical characteristics of healthcare waste are carried out for elimination of its hazard, so that it can be safe to the environment and health.

***Transportation Document (Consignment Note):***

It is the form that contains all data, duly completed and signed by the generator, transporter/carrier, and waste treatment and disposal facilities. It is made up of several copies that travel with healthcare waste shipment and are transported from the health care facility to the waste treatment and disposal facility.

**Dental Healthcare Waste**

**[5, 13, 77, 90, 160-161, 163-168]**

Healthcare waste (HCW) is all waste produced as a consequence of health care activities in hospitals and community settings, and requires classification by the person generating the waste at the point of production. Dental health-care waste is divided into two main categories: hazardous and non-hazardous waste.

***1. Non-hazardous Dental Healthcare Waste***

Non-hazardous healthcare waste is described as waste that is generated by administrative departments and general cleaning work within healthcare facilities, similar to normal household or municipal waste. This constitutes the larger portion (75% - 90%) of healthcare waste and

can be managed by the municipal waste services.

Non-hazardous dental healthcare waste includes:

- a. Domestic waste: such as food, drinks, cans, bottles, plastics, ink cartridges, shredded document papers, cardboard and paper towels.
- b. Offensive or hygienic waste: such as hygiene products and nappies.

## **2. Hazardous Dental Healthcare Waste**

Hazardous waste is waste with one or more properties that are hazardous to the health or environment, e.g. explosive, oxidizing, flammable, irritant, infectious, toxic, carcinogenic, teratogenic, and/or mutagenic. Hazardous healthcare waste is the waste generated from sources contaminated or potentially contaminated with infectious, or chemical sources that poses potential health risk. They constitute a small percentage of the total quantity of dental healthcare waste and pose hazards to individuals, community, and the environment during their generation, collection, handling, storage, transport or disposal.

Hazardous dental healthcare waste includes:

### **a. Infectious Waste:**

This is the waste that contains biological agents such as bacteria, viruses, parasites, and fungi which might cause a disease for individuals susceptible to get infected. Infectious waste includes the cultures and stocks of infectious agents from laboratory work (highly infectious waste) and any discarded contaminated instruments or materials that have been in contact with blood or body fluids of infected persons (i.e. contaminated clinical waste such as gloves, aprons, masks, disposable bibs, swab, gauze, cotton, used impression and bite registration materials, single-use materials and instruments, used custom trays, sutures, and disposable gowns) or animals that might potentially transmit infectious diseases.

According to the standard precautions concept, all patients should be considered as potentially infective. Thus, all clinical waste produced

from the treatment of patients should be considered hazardous waste.

***b. Pathological Waste:***

This is the waste that contains human tissues (including extracted teeth), animal carcasses, blood, blood components, and body fluids. Within this category, recognizable human or animal body parts are also called anatomical waste. Human anatomical wastes are required to be handled according to Islamic Law (Sharia) and should be buried (according to the Islamic Fatwa No. 8099 dated 21 safar 1405H).

***c. Sharp Waste:***

This is the waste that contains sharp items such as needles, glass vials, scalpels, orthodontic wires, broken glass, or any other sharp object that has the potential to cut or puncture through the body.

***d. Chemical Waste:***

This is the waste that contains discarded solid, liquid or gaseous chemicals resulting from diagnostic, therapeutic (including local anaesthetic solutions), and laboratory activities or those used in cleaning and disinfecting or sterilizing procedures. It also includes photographic and radiographic chemicals (developer and fixer), lead foil (within intraoral radiographic film packets), and waste amalgam. Chemical waste from health care may be hazardous or non-hazardous.

Chemical waste is considered hazardous if it has at least one of the following properties:

1. Toxic, flammable.
2. Reactive (explosive, water-reactive, shock-sensitive).
3. Corrosive (e.g. acids of pH <2 and bases of pH >12).

Non-hazardous chemical waste consists of chemicals with none of the above properties, such as sugars, amino acids, saline, glucose, and certain organic and inorganic salts.

***e. Pharmaceutical Waste (Medications):***

These are wastes resulting from preventive, therapeutic activities, or from production and preparation of pharmaceutical products and

medications, including also the expired materials.

***f. Cytotoxic Waste:***

Cytotoxic and cytostatic medicines are deemed hazardous wastes but are not used in routine dentistry.

***g. Compressed Gas Cylinders/Containers Waste:***

These are the empty or damaged cartridges, cylinders of gas, disinfectant containers, and aerosol sprayers that may contain inert gases or gases that might cause adverse health effects, and might explode when exposed to high temperatures or to punctures.

**Responsibilities of Hazardous Healthcare**

**Waste Generators [13, 77, 164-165]**

- Hazardous healthcare waste generators must make efforts to reduce the level of generation of hazardous healthcare waste both in quantity and quality by developing the utilized equipment and tools, adapting clean technology and use of raw material and alternatives of lesser harm to both environment and public health (environmental preferable purchasing).
- A comprehensive program for safe management of waste materials must be established and clearly outlined and disseminated to the relevant staff .
- Each health care facility should obtain a licence from the Saudi Arabian Presidency of Meteorology and Environment (PME) before temporary storing or transporting hazardous healthcare waste outside the location.
- All dental staff involved in handling healthcare waste need training, information, and instruction in the risks associated with healthcare waste, its segregation, handling, storage, and collection; proper management of spillages; and any procedures which apply to their particular type of work.
- Supervisors must ensure that procedures are followed by all staff under their supervision. All staff who generate the waste need to understand that they are personally responsible for

- complying with agreed local procedures.
- Health care workers who transport waste, especially hazardous waste, including expired hazardous drugs, must be trained for such tasks.
  - The housekeeping and cleaning policies outlined in the section on ENVIRONMENTAL INFECTION CONTROL of these Guidelines must be adhered to by the janitorial staff. Each janitorial staff member should be given a copy of the cleaning protocols (based on these policies), as a hand out in their own language, which they can refer to whenever they have any queries about the required procedures.
  - Continuing training programs should be conducted to improve the knowledge of janitorial staff regarding:
    1. The importance of cleaning and safe hospital environment in the control of infection.
    2. The risks associated with healthcare waste.
    3. The proper ways of segregation, handling, storage and collection of healthcare waste.
    4. Personal hygiene.
    5. Procedures for dealing with spillages and accidents.
    6. The appropriate use of personal protective equipment (PPE). Appropriate PPE, including heavy-duty utility gloves, should be worn when handling and transporting clinical and hazardous waste.

### **Health-Care Waste Management**

**[13, 77, 90, 161, 163-166, 169-171]**

The effective management of health care waste must consider the basic elements of waste minimization, segregation and proper identification.

#### ***1. Segregation of Hazardous Healthcare Waste Inside The Health Care Facility***

Appropriate handling, treatment and disposal of waste by type reduces costs and aids in the protection of public health. Subsequently, the amount of hazardous waste that needs to be treated will be minimized or reduced prolonging the operational life of the disposal facility and may gain benefit in terms of conservation of resources. A segregation plan must be developed that includes staff training on segregation of waste.

Considering the transmission routes for infection, good health care waste segregation requires that:

- Waste should be placed in containers (e.g. bins, boxes, strong disposable bags) to prevent direct contact.
- Containers should be kept covered to prevent contact with the open air.
- Sharps and potentially infectious waste should be kept in separate containers in each medical area and located well away from patients.
- Sharps containers should be clearly labeled.
- A color coding system should be established or clear signs placed on containers and bags to differentiate between general and hazardous health care waste.

Each healthcare waste generator must segregate hazardous from non-hazardous waste at the generation site (e.g. clinic, laboratory, CSSD, radiology department). General waste containers placed beside infectious waste containers in patient care areas may aid in better segregation. The waste generator holds the responsibility of segregating and collecting waste in containers specially made for this purpose within the health care facility and its department's as follows:

1. Non-hazardous healthcare waste is to be collected in black plastic bags. These bags are not always doubled but double bags should be used when bags are not sturdy. Non-hazardous healthcare waste should be treated separately and must be segregated from the hazardous healthcare waste in all stages (packaging, collection and transporting inside the facility and

storage) until it joins the stream of domestic refuse or municipal solid waste, and transported to the final disposal places in the landfill (e.g. municipal landfill).

2. Infectious waste is collected in orange- colored plastic bags bearing the phrase “Hazardous Healthcare Waste” (in Arabic and English) along with the biohazard logo (Figure 4) . The infectious waste should be autoclaved before it is sent to the Riyadh landfill area.

**Figure 4**

*The Bio-hazard Logo*



3. Highly infectious waste should, whenever possible, be treated immediately by method recommended in this guidelines. It therefore needs to be packaged in bags that are compatible with the proposed treatment process. Highly infectious microbial cultures such as viruses, TB, or Brucella, are to be collected in plastic bags suitable for pre-treatment by autoclaving within the generation site in the generating department. Such bags are orange in color and bear the phrase “Highly Infectious Waste”, along with the biohazard logo. After autoclaving, the bags are to be placed in orange bags bearing the phrase “Hazardous Healthcare Waste” along with the biohazard logo.
4. Pathological waste: Tissues and human body parts to be placed in red plastic bags bearing the phrase “Bio hazard” in Arabic and English and the biohazard logo. After placing in the bags, such wastes should be kept in special refrigerators until they are buried in accordance to Islamic Sharia. Animal carcasses and animal tissues are to be collected in red bags and pre-



served isolated in a special refrigerator until they are treated and disposed.

5. Sharps wastes should all be collected together, regardless of whether or not they are contaminated. They are to be disposed of in color-coded containers (usually made of metal or high-density plastic), fitted with covers and bearing the phrase “Hazard - Sharp Items” (in Arabic and English) and the biohazard logo. The containers should be rigid, leak proof, and puncture proof.
6. Pharmaceutical Waste (Medications):
  - a. Quantities of expired medications/materials should be returned to the Pharmacy Department for proper disposal.
  - b. Trace medications and pharmaceutical items likely to be contaminated are to be disposed of by collecting them in leakproof containers, then in color-coded plastic bags bearing the phrase “ Chemical Waste-Medications” in (Arabic and English) as well as the biohazard logo.
7. Chemical Waste should be packed in chemical resistant containers and sent to specialized treatment facilities (if available). The identity of the chemicals should be clearly marked on the containers. Hazardous chemical wastes of different types should never be mixed. Liquid Chemical Waste is collected inside color-coded and thick hermetically sealed, leak proof containers, bearing the phrase “Chemical Waste” in (Arabic and English) as well as the biohazard logo. Meanwhile, solid chemicals such as powder materials’ waste are to be collected in color-coded plastic bags bearing the phrase” Chemical Waste-Medications” in (Arabic and English) as well as the biohazard logo. Waste with a high content of heavy metals (e.g. cadmium or mercury) should be collected separately. These wastes can be sent to a waste treatment facility available in the area.
8. Aerosol containers may be collected with general health care waste once they are completely empty. Aerosol containers should not be burnt or incinerated.

## ***Dental Amalgam:***

Dental amalgam is classified as hazardous waste and includes amalgam in any form, as well as materials contaminated with amalgam. Amalgam capsules are also classified as a hazardous waste. Mercury in the environment is bioaccumulative, which means that it can build up in fish and cause health problems in humans and other animals that eat fish. Mercury is a naturally occurring metal; however, about half of the mercury released to the environment comes from human activity.

Of that amount, 53% is emitted from combustion of fuels for energy production and 34% is from the combustion of waste. Sources associated with manufacturers and consumers make up the remaining 13%, with dentistry contributing less than one percent. Although mercury in the form of dental amalgam is stable, amalgam should not be disposed of in the garbage, infectious waste or sharps container. Amalgam also should not be rinsed down the drain.

There are several ways that mercury from dental amalgam can reach the environment:

1. **Wastewater:** Amalgam that is rinsed down drains or escapes from poorly maintained chairside traps, vacuum pump filters, and amalgam separators enters the wastewater stream and eventually the wastewater treatment plant or the septic system. Any mercury contained in treated wastewater will either end up in the sewage sludge, which may be land applied, or in the liquid effluent to be discharged into lakes or rivers.
2. **Medical Waste:** Scrap amalgam, both contact (amalgam that has been in contact with the patient, e.g. extracted teeth with amalgam restorations, carving scrap collected at chair side, and amalgam captured by chair side traps, filters, or separators) and non-contact (excess mix leftover at the end of a dental procedure), should not be treated as infectious waste. Amalgam that is improperly put into biohazard bags might be either incinerated or autoclaved. If amalgam is present in waste that is incinerated, the mercury will volatilize and enter the atmosphere. The volatilized mercury then precipitates to the ground

or a waterbody. If amalgam is present in waste that is autoclaved, the volatilized mercury will escape from the autoclave when the door is opened, presenting an immediate health hazard to dental office staff.

3. Garbage: If amalgam scrap is discarded into ordinary trash, it may eventually be incinerated or placed in a landfill. If discarded amalgam scrap ends up in a landfill, it may lead to soil and/or water contamination.

Dental practices which place or remove amalgam fillings must install chair-side traps, vacuum pump filters, or amalgam separators within the dental unit filter and ensure the amalgam collected is disposed of as hazardous waste. The ability of amalgam separators to remove amalgam from the dental wastewater may be superior to filters and traps used in chairside dental units and vacuum lines. These separator systems are used to capture scrap amalgam in wastewater which is too fine to be removed by a trap.

Amalgam waste should be collected by suitable licensed or permitted waste management facilities where the waste undergoes a mercury recovery process prior to final disposal. The strategies of amalgam waste management falls into two categories: pollution prevention actions and control actions, also called “best management practices.”

- Pollution Prevention: The goal of pollution prevention is to reduce or eliminate the use of toxic or polluting substances at the source. This can be achieved by using amalgam substitutes in cases where they are appropriate, ethical, and economically feasible.
- Best Management Practices: While pollution prevention is the ideal solution for solving the mercury problem, it is not always feasible in practice. Best management practices are economically achievable measures or actions that can be used to control or reduce the entry of pollutants (mercury, amalgam and other dental office wastes) into the environment. The following are best management practices for amalgam waste:
  1. Amalgam waste, amalgam capsules and extracted teeth that

contain amalgam restorations should not be placed in biohazard containers, infectious waste containers or regular garbage.

2. Amalgam waste should not be flushed down the drain or toilet.
3. Devices containing amalgam should not be rinsed under running water over drains or sinks as this could introduce dental amalgam into the waste stream.
4. Precapsulated alloys and a variety of capsule sizes should be used to minimize the amount of amalgam waste generated.
5. Bulk mercury should not be used.
6. Chair-side traps, vacuum pump filters, or amalgam separators should be used to retain amalgam.
7. Line cleaners that minimize dissolution of amalgam should be used. The use of bleach or chlorine-containing cleaners to flush wastewater lines should be avoided.
8. All contact and non-contact scrap amalgam should be salvaged and stored in separate, appropriately labeled containers.
9. Amalgam waste should be stored in wide-mouthed, covered, rigid plastic container (preferably with mercury vapour suppressant) labelled "Contact Amalgam for Recycling", "Non Contact Amalgam for Recycling", or as directed by the recycler. The container lid should be well sealed, and when the container is full, it should be sent to the recycler.
10. After mixing amalgam, the empty capsules should be placed in a wide-mouthed, container that is marked "Amalgam Capsule Waste for Recycling." The container lid should be well sealed. When the container is full, it should be sent to a recycler.
11. Any defective capsules that cannot be emptied should be placed with the non-contact scrap amalgam so they can be recycled (the amalgam recycler should be asked if they will take capsules with scrap amalgam).
12. The recyclers may have their own requirements for the storage, disinfection and shipping of scrap amalgam. These require-

ments should be followed.

13. Amalgam waste and used disposable amalgam capsules should be recycled following the manufacturer's recommendations for maintenance and recycling procedures. Recycling of dental amalgam waste is strongly recommended as a best management practice which may help prevent the release of mercury to the environment. The mercury can be recovered from amalgam wastes through a distillation process and reused in new products.

### ***Radiographic Fixer and Developer Solutions:***

- Used radiographic fixer, the solution left over from X-ray processing, and developer solutions are classified as hazardous chemical waste.
- The used fixer is considered a hazardous waste because of its high silver content.
- X-ray developer and used X-ray fixer should not be mixed.
- The silver-laden used X-ray fixer cannot be flushed down the drain.
- If X-ray developer is accidentally mixed with used X-ray fixer, the mixture must be disposed of through a waste treatment and disposal facilities.
- Waste radiographic developer and fixer solutions should be stored in leak proof containers and collected by a suitably licensed company or waste facility for material recovery.
- Material recovery of used fixer can be done off-site by another company, or it can be done in-house.
- If the dental health institution is on a septic system, the liquid that has gone through the silver recovery process should not be washed down the drain. The recovery process waste may disrupt the proper functioning of the septic system.

### ***Lead Foils, Shields and Aprons:***

- Any packaging containing residues of, or contaminated by, dangerous substances are classified as hazardous waste. In

dentistry this includes the lead foil present in radiographs. The lead content of these items makes them hazardous waste, even if they are recycled for their scrap metal content.

- The lead foil that shields X-ray film, protective lead shields, and lead aprons should not be placed into the trash or into biohazard bags. They should be disposed of by suitable licensed or permitted waste treatment and disposal facilities.
- Manufacturer recommendations should be followed for recycling possibilities for lead aprons that become worn out or damaged.
- Documentation should be obtained from the company handling the lead waste confirming that the waste has been disposed of properly.

### ***Chromium-Containing Cleaners:***

- Many cleaners for x-ray developer systems contain chromium which is considered a toxic substance.
- Pollution prevention can be achieved by using non-chromium containing x-ray developer system cleaners.
- The package label or the material safety data sheet (MSDS) of the cleaner should be checked to see if the cleaner contains chromium, and if it does, it must be managed as a hazardous waste.
- Chromium-containing cleaners should be disposed of by suitable licensed or permitted waste treatment and disposal facilities.

### ***Chemiclave/Chemical Sterilant Solutions:***

- Spent chemiclave solution, the liquid left over from the chemical sterilization of dental instruments, is an ignitable waste because it contains more than 24% alcohol and has a flash-point below 140°F.
- The spent chemiclave solution should be diluted with at least 4 parts of water (4 parts water to one part chemiclave solution) or more before discharging down the drain.

- The chemiclave solution should not be washed down the drain undiluted and should not be placed in the garbage.

### ***Disinfectants, Cleaners and other Chemicals:***

- The label directions on the product container should be followed for guidance on the proper handling and disposal of used disinfectants and cleaners, along with the residue remaining in the product containers.
- The empty container can be recycled or disposed of in the trash.
- Alcohols, ethers, and peroxides are considered ignitable and must not be discarded down the drain undiluted because they could explode.
- These materials are considered to be hazardous waste. Unused products should be disposed of by suitable licensed or permitted waste treatment and disposal facilities.
- Cleaning solution, disinfectant or any other process waste should not be placed into a septic system, regardless of its concentration, because they may disrupt the proper functioning of the septic system.

### ***Fluorescent Bulbs:***

Fluorescent bulbs are hazardous waste and a significant source of mercury. They should not be placed in the trash, instead, they should be recycled.

### ***Batteries:***

- Most, if not all, batteries have hazardous properties and should be recycled.
- Batteries should not be placed in the trash, biohazard bag, or sharps container.
- Certain kinds of batteries—including certain button batteries, some medical batteries, small sealed lead-acid batteries, and other specialty batteries—contain mercury and other metals that are intentionally added, therefore, they should be re-

cycled.

### ***Rechargeable Batteries:***

Batteries such as nickel/ cadmium (Ni/Cd) that are no longer useful are hazardous waste and should also be recycled since they contain lead and cadmium.

## **2. Collection/Transportation Within the Health Care Facility**

Proper collection and transportation is an important component of health care waste management. Its implementation requires the direct involvement of the health care facility maintenance services, and housekeeping services, and cooperation of all the health care personnel. Health care waste collection practices should be designed to achieve an efficient movement of waste from points of generation to storage or treatment while minimizing the risk to personnel.

Collection and transportation of bags/containers of hazardous healthcare waste within the health care facility require using specially designed trolleys (see Specifications for Healthcare Waste Trolleys ) or carts that are dedicated solely for that purpose, and well-trained janitorial staff in order to prevent any leak or spill out of the bags/containers and to guarantee the highest degrees of safety during collection/transportation within the health care facility.

Healthcare waste should be collected at regular intervals to reduce its build up in the facility, and transported to the designated central storage site or waste transfer station. If clinical waste is stored outside the practice for collection, it must be secure and not accessible to outside interference. Suggested collection frequency is once every clinical session or as often as necessary. Time of collection should be at the end of clinical session. Prior to collection and transportation of bags/containers of hazardous healthcare waste, they should be fully-sealed and locked and it should be made sure that they have the data-sticker that reveals their contents, as well as the presence of proper hazard identification and its related labeling including the biohazard logo.

Waste bags should not be filled with more than ¾ of their capacity and should not be pressurized or compacted. All hazardous health



care wastes should be collected in double bags. Bags should not be closed by stapling, and when doubled should be tied separately. Waste bags should not be held close to the collector body or to be held from their bottom. Bags should only be held at the top when handling. The bags or containers should be replaced immediately with new ones of the same type. A supply of new collection bags or containers should be readily available at all locations where waste is produced.

In cases when hazardous healthcare waste spill or leak out of plastic bags, containers, or trolleys, such waste must be considered as extremely hazardous. This requires an immediate action. Cleaning, disinfection, and safety measures must be taken when and where a leakage is identified. Trolleys for collecting and carrying hazardous healthcare waste are to be cleaned, washed, and disinfected on a daily basis with an appropriate disinfectant (such as chlorine compounds, and phenolic compounds), by trained janitorial staff, under the supervision of the person responsible for hazardous healthcare waste in the health care facility, and in a special location.

Cleaning and disinfectant solutions must be treated (e.g. diluted) before drainage or disposal.

### ***Data Stickers:***

Hazardous healthcare waste generators must attach stickers to containers and bags of waste prior to their transportation to stores within the health care facility or waste treatment and disposal facility. The sticker attached to bags/containers should have the biohazard logo and the sticker should be of proper size and the information on the sticker must be written/ printed in waterproof and permanent ink. The stickers should contain the following data:

- a. Waste generator name (facility name).
- b. Site name (section or department).
- c. Generated waste type as per its classification as described earlier.
- d. Weight and quantity of waste in the bag/container.

- e. The name of the person collecting the waste and attaching the sticker.
- f. Date and time of collection.
- g. Transportation date and time to the disposal facility.

### **3. Temporary Storage Inside The Health Care Facility**

Every health care facility needs to store hazardous healthcare waste temporarily inside the facility until they are transported to a Waste Treatment and Disposal Facility. The bags or containers of waste should be stored in a designated area, room, or building of a size appropriate to the quantities of waste produced and the frequency of collection. In cases where the health care facility lacks the space, daily collection and disposal should be enforced. The health care facility should obtain a licence from the PME before temporary storing hazardous healthcare waste.

The hazardous waste and domestic waste should have different rooms for storage. If not possible, a hard barrier made of impenetrable material should separate the hazardous and non- hazardous waste.

Biodegradable general waste should not be stored longer than 1-2 days to minimize microbial growth, putrefaction, and odours. The storage period for hazardous health care waste should not exceed 24 hours. If the waste must be stored longer than 1 day, refrigeration at 4°C or less or application of treatment like chemical disinfection is recommended.

#### **Requirements of the storage area:**

1. Should be located within the health care facility so as to be a temporary collection site/center for the health care hazardous waste generated by that health care facility.
2. Location should be appropriate and cause no pollution or harm to human health or environment.
3. Should be located away from dental clinics and direct patient care areas, laboratories, operation rooms, or any public access areas.

4. Should be distant from food storage areas, kitchens, and places where food is prepared.
5. Should be easily accessible for storage, transport, and cleaning.
6. Must be in a well-sealed location with a durable concrete floor and constructed with materials that protect the building against water leakage, rain, spread of bad smells, and the access of rodents, insects, birds, and stray animals; can stand frequent cleaning, scrubbing, and disinfecting; and equipped with a proper sewage system.
7. Should be equipped with safety and fire protection tools in addition to an emergency kit.
8. Should be equipped with proper lighting, ventilation, and air conditioning, with the temperature being between 15-18°C.
9. Should have a water supply for cleaning purposes.
10. Should be equipped with the necessary protective clothing; waste bags or containers; and cleaning tools and supplies for frequent cleaning of the area, as well as cleaning of spills, and any other emergency cleaning needs (see ENVIRONMENTAL INFECTION CONTROL).
11. Should be managed by competent personnel specialized in handling hazardous healthcare waste.
12. Should only store waste which has been filled in the recommended containers or plastic bags.
13. Access should be restricted to the authorized personnel only.
14. The entry should have a clear hazard sign that states the storage contents (in Arabic and English), e.g. "CAUTION: BIOHAZARDOUS WASTE STORAGE AREA- UNAUTHORIZED PERSONS KEEP OUT"
15. It should be possible to lock the storage area to prevent access by unauthorized persons.

#### **4. Transporting Hazardous Healthcare Waste**

If the generator of hazardous healthcare waste needs to transport such waste to another site outside the facility in which it was generated, the generator is responsible for implementation of all of the following procedures related to the transportation of such waste:

1. Packaging hazardous healthcare waste and labelling it correctly in accordance with the “Segregation of Hazardous Healthcare Waste Inside Health Care Facility” and “Data Stickers” sections.
2. Taking adequate steps to ensure that the waste is managed safely and kept secure.
3. Refraining from delivery of such waste to persons or parties not licensed by the PME for transporting such types of waste.
4. Refraining from delivery of such waste for transport outside the facility without an attached manifest paper or consignment notes (see following section on “Documentation and Records”).
5. Refraining from delivery of such waste to a waste treatment and disposal facility that is not licensed by the PME.

#### ***Documentation and Records:***

A key element of the effective management of health care waste is keeping track of the waste. The generator of the hazardous healthcare waste should always keep records of the data pertaining to all related aspects of the hazardous healthcare waste, such as generation, storage, transport, and disposal. The generator of the hazardous healthcare waste should provide all concerned parties with a copy of such records periodically, as determined by such parties.

The consignment system (utilization of consignment notes) for tracking of waste must be implemented. Each collection of hazardous waste must be accompanied with a hazardous waste consignment note. The generators of the hazardous healthcare waste may produce their own consignment note or use consignment notes supplied by a waste contractor.

When the waste transporter receives the waste, the transporter must provide the waste generator with a copy of the consignment note for the generator's waste records. The transporter and the generator shall separately maintain a copy of the consignment note. The transporter should have the consignment note in his possession in the vehicle while transporting the waste. The tracking document should be available upon demand by any traffic enforcement agency personnel. The transporter shall provide the facility receiving waste with a copy of the original tracking document. Copies of the consignment note should be retained by all parties for a minimum of two years.

The consignment note shall include, but is not limited to, the following information:

- The name, address, telephone number, and accreditation number of the transporter.
- The name, address, and telephone number of the generator.
- The name, address, telephone number, permits number, and the signature of an authorized representative of the approved facility receiving the waste.
- The date that the waste is collected or removed from the generator's facility, the date that the waste is received by the transfer station, and the date that the waste is received by the treatment facility.
- Description of the waste:
  - The type of waste transported.
  - The quantity of waste transferred, by weight where possible.
  - How it is packed.
  - The type of container.
  - The process that produced the waste.
  - Anything unusual about the waste that may pose a problem.
  - Any information, advice, or instructions about the handling, recovery, or disposal of the waste.

## **5. Treatment and Disposal of Healthcare Waste**

Prior to disposal in landfill sites, the traditional method for reducing the volume and mass of healthcare waste and making it safe has been incineration. But a growing body of evidence has questioned the efficacy and safety of incineration. Of particular concern is pollution from exhaust emissions, especially when incinerators are located in residential or environmentally sensitive areas. For instance, viable bacteria can be released from exhaust flues under certain circumstances. Temperature gradients form in the incinerator exhaust stack, and pathogenic bacteria can survive in the cooler zones at the base of the stack. These and similar concerns have prompted the introduction of more reliable and environment-friendly disinfection methods referred to collectively as “alternative technology methods”, and which employ heat, chemicals and irradiation. (Table 23)

Heat processes can be divided into high- and low-temperature methods.

### **I. High Temperature Processes**

#### **1. Incineration**

It is the process in which solid, liquid and gas wastes are disposed of by burning at high temperatures, and which generates gas or other materials /components. Healthcare waste incinerators are required to meet certain temperature and emission limits. Generally they have a primary combustion chamber operating at 800–1000°C and a secondary chamber that operates at a minimum temperature of 1100°C, with a retention time for the combustion gases of two seconds.

The incinerator plant also includes gas-cleaning equipment to reduce emissions into the air. This equipment deals with compounds such as hydrogen chloride and sulphur dioxide, which form as a result of chlorine and sulphur compounds present in the original waste material.

Incineration is the best method to treat metallic and chemical waste.

#### **2. Pyrolysis**

Pyrolysis involves the high temperature (545–1000°C) heating of

waste in the absence of oxygen to produce a synthesis gas. The synthesis gas produced by a pyrolysis system is mixed with air and combusted in a secondary chamber. For general wastes, the synthesis gas produced by pyrolysis can be cleaned and combusted in an engine, but this is avoided with healthcare waste where security of destruction is paramount.

As with incineration, the secondary combustion component must meet a temperature of 1100 degrees and retain the exhaust gases for two seconds. By heating the waste at the initial temperatures, these systems destroy pathogens and reduce the volume of clinical healthcare waste.

### **3. Plasma Technology**

In a plasma system, an electric current is discharged through an inert gas (for example argon) to produce a plasma with a temperature as high as 6000°C. Healthcare waste is fed to the chamber where the plasma is present and is heated to temperatures between 1300 and 1700°C, destroying all pathogenic microbes and converting the waste into a glassy rock or slag, ferrous metal (if present), and a synthesis gas.

As in the pyrolysis process, the synthesis gas produced is often combusted in a secondary chamber, although the very high temperatures in the plasma chamber mean the gas can be fed to an engine generator as an alternative. The use of an engine generator can result in plasma systems exporting power to the electric grid.

### **4. Gasification**

The gasification process is similar to the pyrolysis process, except for the fact that small amounts of air are introduced to the primary treatment chamber. The air added does not support full combustion, but is enough to release more energy from the waste in the primary chamber. It therefore raises the temperature in the primary chamber to a higher level (900–1100°C) and produces ash rather than char.

## **II. Non-Burn/Low Temperature Alternative Technologies**

### **1. Heat (Thermal) Disinfection Systems**

These systems rely on heating the waste to a fixed temperature for

a specified time to deactivate the infectious elements in the waste. The continuous monitoring and recording of waste temperature and time are critical to ensuring the required temperature level is achieved for the entire body of the waste.

## **2. Autoclaves**

In autoclaving, saturated steam is introduced into a vessel above atmospheric pressure. Some autoclaves are designed to shred waste during the treatment cycle; other systems rely on the use of a pre-treatment process to macerate (soften, or break down by soaking) the waste before the waste is heated.

The use of internal paddles/arms/ridges designed to mix the waste inside the autoclave chamber may not meet the requirements for maceration.

## **3. Steam Auger**

This industrial thermal disinfection process operates at atmospheric pressure using a combination of residence time and temperature to treat the waste and render it safe. Waste is shredded prior to its entry into a steam auger, where it is turned and treated with steam to achieve the required inactivation of pathogens.

## **4. Dry Heat**

Some waste treatment systems available for both large (for example hospitals) and small-quantity generators (for example GP/dental practices) thermally inactivate potentially pathogenic microorganisms through the use of electrically-generated heated air, oil or molten plastic.

## **5. Microwaves**

Microwaves are electromagnetic waves with a frequency between radio waves and infrared waves on the electromagnetic spectrum. When applied to the treatment of waste, the mechanism of microbial inactivation is thermal (temperature in the range of 95-98°C).

It is important for the waste to be wet, either as a result of moisture naturally occurring in the waste stream or by the addition of moisture in the form of steam. The combination of the two – microwaves and



moisture – creates the thermal process.

Some treatment processes utilize microwaves to heat water to form steam, which is then applied to the infectious waste stream. “Dry” microwave systems are also available. These use direct microwave energy in a nitrogen atmosphere to treat the waste and produce higher treatment temperatures than those used by “wet” microwave technologies.

### **6. Macrowaves**

These systems apply low-frequency radio waves to inactivate microbes contained within the waste. The macrowaves heat the waste from the inside of the materials to their external surfaces.

### **7. Chemical Disinfection Systems**

Chemicals commonly used in the clinical setting in disinfecting environmental surfaces and medical devices are sodium hypochlorite, chlorine dioxide, peracetic acid, glutaraldehyde, and quaternary ammonium compounds.

The waste must first be shredded in order to bring all surfaces of the waste into direct contact with the chemicals. Some systems combine heat with the chemicals to reduce the treatment cycle. The key requirements are that:

- a. the disinfectant has the ability to act on all the key pathogen groups
- b. the disinfectant is maintained in the waste at sufficient concentration or is given enough time to achieve the required level of treatment for each of the key pathogen groups; and
- c. the treated waste (which may be highly absorbent) should not be rendered chemically hazardous due to the presence of residual disinfectant.

### **8. Other Chemical Systems**

Other chemical processes have a potentially wider application than disinfection. Alkaline hydrolysis exposes the waste to hot alkali for a period of several hours and can, for example, reduce carcasses to

bone shadows. The organic rich outflow from these units is likely to have a very high biological oxygen demand, and should be subjected to additional treatment to ensure that effluent is dewatered, with only the water being discharged to foul sewer.

### **9. Landfill**

Infectious waste is banned from landfill, although it can be pre-treated (for example by alternative treatment) so that it is non-infectious and suitable for landfill. Some types of healthcare waste may be disposed of directly to landfill (for example non-infectious offensive/hygiene waste).

## **Specifications of Plastic Bags and Containers of Healthcare Waste**

**[13, 77, 165]**

Plastic bags, and sharps containers should not contain Polyvinyl Chloride.

### **1. Standards of the plastic cases/containers:**

Plastic bags/containers used for collecting hazardous healthcare waste should comply with the following standards:

- a. Waste bags should be of good quality, and be water repellent.
- b. The thickness should not be less than 100 micron for high density plastic, and not less than 200 microns for low density plastic.
- c. Bags should have ribbon or plastic lock tie to close the bag.
- d. Maximum total capacity is 100 litres.
- e. Should be compatible in size with the waste bin that it is placed in.
- f. Should be of the recommended color code for the type of waste indicated (Table 22).
- g. Should be marked as “Hazardous Waste” or “HIGHLY INFEC-

TIOUS” with biohazard logo.

- h. Bags used for collecting highly infectious waste (such as culture plates with TB, Brucella, or viruses) and requires initial treatment with autoclave (for example) must be made of a plastic material that withstands high temperatures without melting, and enhances the sterilization process by allowing easier passage of steam into the waste.

**2. Specifications of Waste Bins in Which Bags are Stored in:**

- a. The size should accommodate the bag used.
- b. It should have a hermitical seal, foot pedal type.
- c. It should be easy to clean and made of material that can be disinfected.
- d. The statement “hazardous healthcare waste” should be written on the sides and cover of the waste bins used for orange bags with a biohazard logo.

**3. Sharp Waste Containers Standards:**

- a. Made of non-puncture, leak proof materials.
- b. Equipped with a hermetic seal (attached cover with a hole that allows inserting sharp tools).
- c. Yellow in color with a biohazard logo and the following words should be printed: “Hazard - Sharp Items “ (in Arabic and English).
- d. Its size should be adequate so as to be carried by one hand and it should be provided with a handle for that purpose.

**4. Chemical Waste Containers Standards:**

- a. Made of strong leak proof materials.
- b. Made of material non reactive with the chemical waste.
- c. Equipped with a hermetic seal.
- d. Maximum total capacity is 50 liters.

- e. The statement “ Chemical Waste” or “Medications” in (Arabic and English) should be written on the sides of the container as well as the biohazard logo.

**5. Specifications for Healthcare Waste Trolleys (that will be used inside the health care facility):**

- a. The trolleys should have clear indications (e.g., color codes) to specify the category of waste they carry.
- b. The trolley used for hazardous healthcare waste should be clearly labeled with the bio-hazard logo.
- c. It should be made of a material not affected by acids or alkaline, and easily cleaned/disinfected.
- d. It should guarantee efficiency upon loading and unloading.
- e. It should be leak proof
- f. It should be equipped with a cover that can be hermetically sealed.
- g. It should have surfaces and angles that are easy to clean and has no sharp edges that could damage waste bags or containers.
- h. It should have an adequate size to accommodate the transportation of 10 bags (minimum) in one time.
- i. It should be equipped with handles to ease the movement.
- j. It should move smoothly and be equipped with wheels.

**Table 22***Color Coding Recommended for Waste Bags or Containers*

Type of Waste	Color Case or Container
Highly infectious waste (such as culture plates)	Orange clearly marked «HIGHLY INFECTIOUS» (Arabic and English) with biohazard logo. Leak-proof and strong plastic bag, or container for autoclaving
Infectious waste	Orange clearly marked «Hazardous Waste» (Arabic and English) with biohazard logo Leak-proof plastic bag, or container
Human and animal body parts and organs	Red clearly marked «Hazardous Waste» (Arabic and English) with biohazard logo Leak proof plastic bag or container
Sharps	Yellow clearly marked « Hazard - Sharp Items « (Arabic and English) with biohazard logo Puncture-proof containers
Non-risk healthcare waste	Black Plastic bag or container

**Table 23***Common Techniques to Treat Hazardous Medical Waste*

Treatment technique	Waste that can be treated	Advantages	Disadvantages
Chemical Treatment	Infectious waste Sharp items	One of the effective methods to reduce the microbial load in hazardous medical waste.	Disinfectants used are hazardous chemicals that should be used with caution when storing or handling them. The size of waste will not be minimized if it is not shredded.
Microwave	Infectious waste Sharp items	Gases emitted to the environment are very low in levels. The size of waste is minimized around 75% by shredding.	It requires shredding the waste and wetting it with water. It is not sufficient to treat other kinds of hazardous medical wastes.
Autoclave	Infectious waste Sharp items	Effective method to reduce the microbial load in hazardous medical waste. Low operational costs.	It is not sufficient to treat other kind of hazardous medical waste. The size of waste will not be minimized if it is not shredded.
Incineration	All hazardous medical waste except for radioactive waste, compressed gas cylinders/containers waste, amalgam and liquid waste	May be used to treat most kinds of hazardous medical waste. Minimizes the size of waste greatly.	Gases emitted due to combustion are in very high levels that requires use of an advanced technology (with high costs) to control the gaseous emissions.

Source: GCC [77]

## APPENDIX A

### Sample Screening Form

( Name of Device )

This form collects your opinions and observations following screening of ( Name of Device ) to determine its acceptability for use in a clinical setting.

**The device must not be used on patients during this initial screening phase.**

**Date:**

**Product: Name, brand, company:**

**Your position or title:**

**Your occupation or specialty:**

	Clinical Considerations	Does not Meet Expectations	Meets Expectations	Exceeds Expectations
1.	The device permits repeated use during treatment on the same patient.	1	2	3
2.	The weight and size of the device is acceptable.	1	2	3
3.	Effectiveness of the device may be evaluated by the operator during use.	1	2	3
4.	The size and configuration of the device permits a clear view of the work site and instrument tip.	1	2	3
5.	No excessive force is required to use the device.	1	2	3
6.	The size and configuration of the device permits use in all mouth sizes and access to all areas of the mouth.	1	2	3
7.	The worker's hands can remain away from danger during activation of the safety feature.	1	2	3
8.	The device permits multiple uses on the same patient.	___ No	___ Yes	
9.	The device is capable of performing all tasks the traditional device performs.	___ No	___ Yes	
10.	The device is compatible with other items used during patient treatment.	___ No	___ Yes	
11.	The device may be decontaminated using the facilities available in the College.	___ No	___ Yes	
<b>Does the product meet the needs of your clinical practice based on the above criteria?</b>		___ No	___ Yes	

## Screening Form

( Name of Device )

Safety Feature Considerations		Does not Meet Expectations	Meets Expectations	Exceeds Expectations
12.	The safety feature can be activated with one hand.	1	2	3
13.	The safety feature is integrated into the device.	1	2	3
14.	The safety feature provides a means of protecting the operator between uses.	1	2	3
15.	A visible or audible cue provides evidence of safety feature activation.	1	2	3
16.	The safety feature is easy to recognize and use.	1	2	3
17.	Once activated, the safety feature permanently isolates the danger and cannot be purposefully or accidentally deactivated under normal use conditions.	1	2	3
18.	The safety feature activates by itself.	____No	____Yes	
General Product/Manufacture Considerations		Does not Meet Expectations	Meets Expectations	Exceeds Expectations
19.	The manufacturer can provide the device in needed quantities.	1	2	3
20.	A full range of sizes is available.	1	2	3
21.	The company provides free samples for in-use evaluation.	1	2	3
22.	The company has a history of responsiveness to problems.	1	2	3
23.	The manufacturer can provide information on the necessary decontamination requirements	____No	____Yes	



## Screening Form

( Name of Device )

Practical Considerations		Does not Meet Expectations	Meets Expectations	Exceeds Expectations
24.	The device is packaged conveniently.	1	2	3
25.	The device is easy to remove aseptically from the package.	1	2	3
26.	Instructions are included in the packaging.	1	2	3
27.	Instructions are easy to follow and complete.	1	2	3
28.	Instructions are provided in more than one form (paper, videotape, website, or computer disk.)	1	2	3
29.	Use of the safety device will not increase the volume of waste.	1	2	3
30.	The shape and size of available waste containers will accommodate disposal of this device.	1	2	3
31.	This is a single use, disposable device.	____No	____Yes	

THE DEVICE SHOULD BE CONSIDERED FOR FURTHER CLINICAL EVALUATION.

\_\_\_\_No

\_\_\_\_Yes

**Additional comments for any responses of “Does Not Meet Expectations” or “No”**

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## APPENDIX B

### Sample Device Evaluation Form

( Name of Device )

**This form collects your opinions and observations after pilot testing (name of device).**

Date:

Product: Name, brand, company:

Number of times used:

Your position or title:

Your occupation or specialty:

1. Did you receive training on how to use this product?  
 Yes [Go to next question]       No [Go to question 4]
2. Who provided this instruction? (Check all that apply)  
 Product representative     Staff member       Other
3. Was the training you received adequate?  
 Yes       No
4. Compared to other of your sex, how would you describe your hand size?  
 Small       Medium       Large
5. What is your sex?     Female       Male

Please answer all questions that apply to your duties and responsibilities. If a question does not apply to your duties and responsibilities, please leave it blank.

	During the Pilot Test of this Device...	Strongly Disagree	Dis-agree	Neither Agree nor Dis-agree	Agree	Strongly Agree
6.	The weight of the device was similar to that of a conventional device.	1	2	3	4	5
7.	The device felt stable during assembly, use, and disassembly.	1	2	3	4	5
8.	The device fit my hand comfortably.	1	2	3	4	5
9.	The device was easily amendable to repeated use.	1	2	3	4	5
10.	Effectiveness of the device was easily determined during use.	1	2	3	4	5
11.	I had a clear view of the work site and instrument tip.	1	2	3	4	5

## Device Evaluation Form

( Name of Device )

	During the Pilot Test of this Devices	Strongly Disagree	Dis-agree	Neither Agree nor Dis-agree	Agree	Strongly Agree
12.	The device did not appear to increase patient discomfort.	1	2	3	4	5
13.	The device performed reliably	1	2	3	4	5
14.	I was able to use the device in all mouth sizes and all areas of the mouth.	1	2	3	4	5
15.	I used the device for all of the same purposes for which I use the conventional device.	1	2	3	4	5
16.	Activating the safety feature was easy.	1	2	3	4	5
17.	The safety feature was easy to recognize and use.	1	2	3	4	5
18.	The safety feature did not activate inadvertently, causing me to use additional devices (units).	1	2	3	4	5
19.	The safety feature functioned as intended.	1	2	3	4	5
20.	The instructions were easy to follow and complete.	1	2	3	4	5
21.	I could have used this product correctly without special training.	1	2	3	4	5
22.	The “feel” of the device did not cause me to change my technique.	1	2	3	4	5
23.	This device meets my clinical needs.	1	2	3	4	5
24.	This device is safe for clinical use.	1	2	3	4	5

**Additional comments for any responses of “Strongly Disagree” or “Disagree”**

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