**Transmission** **and** **Prevention of Microbial Infection**

**in Dental Healthcare Settings**

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**Abstract**

Infectiontransmissionand prevention in dentistry is an important subject that has gained more interest in recent years. Many publications are available on the topic of compliance with infection prevention and control in dental health-care facilities all over the world. The approaches of developing and developed countries show wide variation, but the principles of infection prevention and control are the same globally. However, little is known about the real risks of cross-infection, specifically in the dental healthcare status. This research is a systematic review and global perspective of the available literature on infection prevention and control in oral health-care facilities. Five topics, concerning infection transmission and prevention measures, were investigated: transmission of infection in oral healthcare, prevention the spread of infection, environmental infection control, disinfection and sterilization andspecial considerations. Facts from the literature HIV, Hepatitis viruses (B and C), *Mycobacterium* spp., *Pseudomonas* spp., *Legionella* spp. and multi-resistant bacteria are presented. There is evidence that Hepatitis B virus is a real threat for cross-infection in dentistry. For the above reasons, the real risks of cross-transmission are likely to be higher. Therefore, there is a need for prospective longitudinal review in this area, to determine the real risks of cross-infection in dentistry and this will assist the adoption of effective hygiene procedures in dental practice. The aim of this research was primarily to view the importance of microbial transmission and infection prevention in dental healthcare settings based on the information and evidences available in the current literature.

**Keywords:** oral health care, Infectiontransmission,cross-transmission, cross-

infection, infection prevention.

**Introduction**

Dentists and dental staff might be occupationally exposed to infectious pathogens and contaminated materials, including body substances and contaminated supplies, equipments, environmental surfaces and water or air. Cross-infection can be defined as the transmission of infectious agents between patients and staff within a clinical environment (1). Infection control, which is one of the most discussed topics in dentistry, has become such an integral part of the practice to the extent that dental health workers no longer question its necessity (2).

Understanding the modes of transmission of infectious organisms and knowing how and when to apply the basic principles of infection prevention is critical to the success of an infection control program (3, 4, 5, 6). The oral cavity is a natural habitat for a large number of microorganisms. This ecological stature can be a reservoir for opportunistic and pathogenic microorganisms that can pose a risk for cross-infection and may even cause systemic infections (7, 8, 9, 10). This is of particular importance in the case of routine dental practice, as the risk of exposure to microorganisms in the oral cavity is increased due to the open and invasive nature of the procedures. It is important to consider that the pathways of contamination can be bidirectional (11, 12). An infectious microorganism may be transferred from the patient to the dental team, but also vice versa (13, 14).

Moreover, another infectious association is the transfer of pathogens from patient to patient, without the mediation of the dental staff, but rather through a surface located in the dental practice, or a device or instrument used during dental procedures (4, 15, 16). This can apply in the case of inadequate sterilization of the dental instruments or disinfection of the dental unit (17, 18). The possibility also exists that pathogens present in dental unit waterlines (DUWLs) could be spread by aerosols created by dental hand-pieces, presenting a risk for both the patient and members of the dental team (19, 20). There are a number of possible means by which transmission of viral and bacterial pathogens can occur in the dental practice. The patient's saliva and blood are major vectors of cross- transmission. Blood-borne contamination can occur by exposure to the infectious material, the highest infectious risk of this type is associated with accidental punctures by contaminated needles or injuries by sharp instruments (16, 21, 22, 23).

Insufficient cross-contamination control, such as improperly sterilized dental instruments, is also a possible device-borne means of pathogen transmission (24). Emanation of the pathogens through the spray of the hand-pieces of the dental unit can also be considered an air-borne or water-borne means of transmission, which may affect both the patient and the dental team (25, 26). Air-borne infections can also occur via an inefficient ventilation system in the dental practice environment, whereby contaminated air may be withheld or recycled. Overall, the risk of any such transmission depends on the dose of the pathogens transmitted, the virulence of the pathogen, as well as the frequency or probability of exposure to the infectious material and the state of the host immune responses (27, 28, 29). The aim of this research was toview the importance of microbial cross-infection and prevention in dental healthcare settings based on the information and evidences available in the current literature.

**Materials and Methods**

A systematic review on global literature addressing infection-control in dental health care was undertaken. The search terms included: oral healthcare facilities, chain of infection, transmission of infection, cross-infection, infection prevention, dental clinics.

The present review covers global studies published about this subject in the specialized scientific journals and guidelines from 2000 to 2015. Also, several government agencies and professional organizations have a direct influence on dentistry, infection control, and other health care safety issues. In addition to issuing recommendations and regulations some have regulatory roles and others are advisory. These agencies and organizations, ]i.e., American Dental Association (ADA), Centers for Disease Control and Prevention (CDC), National Health and Medical Research Council (NHMRC) and World Health Organization (WHO)[ , can serve as an excellent resource for information on infection transmission, infection prevention, occupational health issues and educational materials.

 This information is particularly focused on the infection transmissionand prevention practices in oral health care settings.

**Results and Discussion**

All selected publications were further scrutinized for adherence to the following points: demonstrate the chain of infection, modes of transmission of infection in healthcare facilities, cross-infection and prevention in dental healthcare facilities, precautions and their role in the prevention of transmission of infection.

 The outcome measures of the selected publications through this research were focused on five topics: infection transmission in oral healthcare settings; prevention the spread of infection; environmental infection control; the disinfection and sterilization; and special considerations.

**Topic 1:** **Infection Transmission in Oral Healthcare** **Settings**

Dental patients and dental health care personnel can be exposed to pathogenic microorganisms including Human Immunodeficiency Virus (HIV), Hepatitis B Virus (HBV), Hepatitis C Virus (HCV), herpes simplex virus (types 1 and 2), *Mycobacterium tuberculosis*, *Legionella pneumophila*, staphylococci, streptococci, and other viruses and bacteria that colonize or infect the oral cavity and respiratory tract (6, 28, 29, 70).

1. **Transmission of infection**

The pathogenic microorganisms can be transmitted in dental settings through direct contact with blood, oral fluids and other patient materials or indirect contact with contaminated objects like instruments, equipment, or environmental surfaces (9, 12, 22). Another means of transmission is through contact of conjunctival, nasal, or oral mucosa with droplets containing microorganisms generated from an infected person and propelled a short distance by coughing, sneezing, talking or aerosols and spatters (15, 20). Infection through any of these routes requires that all of the following conditions be present:

1. A pathogenic organism of sufficient virulence and in adequate numbers to cause disease.
2. A reservoir or source that allows the pathogen to survive and multiply (e.g., blood).
3. A mode of transmission from the source to the host.
4. A portal of entry through which the pathogen can enter the host.
5. A susceptible host (i.e., one who is not immune).

Occurrence of these events provides the so-called chain of infection (13). Effective infection-control strategies prevent disease transmission by interrupting one or more links in this chain.

1. **Modes of transmission:**

In healthcare settings, infectious agents can be transmitted by one or more of the following ways:

1. Contact transmission.

 Direct or contact transmission occurs when the transfer of microorganisms results from direct physical contact between an infected or colonized individual and a susceptible host, for example a health care workers (HCW’s) contaminated hands touch a vulnerable site (such as a wound) on a patient (30). Indirect transmission involves the passive transfer of an infectious agent to a susceptible host via an intermediate objects or formites. Examples of intermediate objects include instruments and other environmental surfaces (27).

1. Droplet transmission.

 Droplet transmission occurs when respiratory droplets generated via coughing, sneezing or talking contact susceptible mucosal surfaces, such as the eyes, nose or mouth (15). Transmission may also occur indirectly via contact with contaminated formites with hands and then mucosal surfaces. Respiratory droplets are large and are not able to remain suspended in the air thus they are usually dispersed over short distances.

1. Airborne transmission.

 Airborne transmission refers to infectious agents that are spread via droplet nuclei (residue from evaporated droplets) containing infective microorganisms (31). These organisms can survive outside the body and remain suspended in the air for long periods of time. They infect others via the upper and lower respiratory tracts.

1. **Methods of reducing the spread of infection**

Standard precautions refer to those work practices that are applied to everyone, regardless of their perceived or confirmed infectious status and ensure a basic level of infection prevention and control (10, 18, 32, 33). Implementing standard precautions as a first-line approach to infection prevention and control in the healthcare environment minimizes the risk of transmission of infectious agents from person to person, even in high-risk situations. The standard precautions include:

1. Hand hygiene, before and after every episode of patient contact.
2. The use of personal protective equipment (PPE).
3. The safe use and disposal of sharps.
4. Routine environmental cleaning.
5. Reprocessing of reusable medical equipment and instruments.
6. Aseptic non-touch technique.
7. Waste management.

**Topic 2: Prevention the Spread of Infection**

This section is focusing on different methods for prevention of spread of infection from the patient to oral health care worker or vice versa. The methods are as follows:

1. **Personal protection by immunization**

Dental Health Care Providers are at risk for exposure to, and possible infection with, infectious organisms. Immunizations substantially reduce both the number of dental health care providers susceptible to these diseases and the potential for disease transmission to other health care providers and patients (34).

As a preventative measure, it is imperative that all HCWs inclusive of students who come in contact with blood or other potentially contaminated body fluids receive the prophylactic Hepatitis B vaccine on commencement of employment

[Everyone have to get 3-doses (dose 1, dose 2 in 1 month, dose 3 approximately 5 months after dose 2)].

1. **Personal hygiene and** **care of hands**

Personal hygiene and care of hands have been identified as the most important infection-control precautions to prevent transmission of diseases (35). Transfer of health care-associated cross-infections has been linked to the hands of HCWs in an estimated 20–40 % of cases. To enable oral health care workers (OHCWs) to execute routine hand hygiene before and after each patient contact session, the minimum requirements include the availability of clean water, adequate hand washing facilities, patient-placement facilities, correct storage of sterile supplies and other conditions relevant to the physical working environment (36). Fixed hand-hygiene facilities, including separate basins for instrument cleaning, hand hygiene and patient rinsing, are some of the routine challenges for providing patient care.

The use of alcohol-based hand-sanitizers or hand rubs to be utilized as replacement for routine washing with soap and water, particularly when hand-wash basins are not available. The use of these products is contraindicated when hands are visibly contaminated (37). During 2009, the World Health Organization (WHO) endorsed these guidelines to improve hand-hygiene practices throughout all health-care facilities (38). In addition, findings from Europe indicate that oral health-care professionals there do not wash their hands according to the Centers for Disease Control and Prevention (CDC) recommendations for oral health-care facilities (39).

Adequate hand-hygiene practices, such as frequent use of soap and water and sometimes alcohol-based hand sanitizers, were maintained by more than 75% of oral health-care practitioners investigated in the USA (35). In the UK it was reported that compliance with hand hygiene was not high enough, and when applied, the methods used were outdated (40). Results of hand-hygiene practices in this UK study point out that bar soaps were still used and nail brushes were present in 22% of facilities (40). In actual fact, the use of bar soaps and nail brushes is discouraged in current UK guidelines/recommendations (17). Studies on personal hygiene and the care of hands in oral health-care facilities in developing countries are limited. In one study, Nigerian respondents strongly agreed that the transmission of diseases to patients can be prevented through application of appropriate hand hygiene (39). In Brazil, the use of soap and paper towels in public oral health-care facilities was found to be significantly less than in private practices (41). Bar soaps used in oral health-care facilities in India were found to be contaminated with organisms such as *Pseudomonas aeruginosa, Acinetobacter* spp.*, Enterobacter* spp., *Staphylococcus aureus* and *Staph. epidermidis* in more than 90% of the samples taken (42). This supports the use of automated soap dispensers and liquid hand hygiene products, as recommended in the CDC guidelines for oral health care, which actively discourages the use of bar soaps.

Research has shown that the unpredictable perforation rate of gloves presents specific challenges, particularly during high-exposure procedures such as oral and maxillofacial surgery. The results of a Japanese study suggested that double gloving may offer a protection rate of up to 95% (43).

1. **Personal protective equipment**

Personal protective equipment (PPE), including protective clothing, masks, protective eyewear and disposable gloves, should be worn during any clinical contact. PPE acts as an important safety barrier to prevent exposure of the skin and mucous membranes of the OHCWs (44).These are equipment designed to protect the skin and the mucous membranes of the eyes, nose, and mouth of oral health worker from exposure to blood or other potential infectious material. At the foundation of any infection-control program is the use of standard precautions, which includes wearing PPE, which should be applied at all times in oral health-care procedures, regardless of a patient’s suspected or confirmed medical history of infection (5). When used appropriately and in combination with other protective measures, PPE forms an effective barrier against transmission of any infection. The oral health worker should follow the following instructions when attending to a dental patient:

1. Use protective gowns or coat or apron while in dental surgery.
2. Put on a surgical face mask and eye shield / glass while conducting any dental procedure. Remember to change the mask as frequent as needed.
3. Hands must be checked for cuts or abrasions before putting on the gloves and lesions should be covered with a moisture resistant occlusive dressing.
4. Operator should consider double gloves for complex dental procedures.
5. Always wash your hands with the soap or detergent and dry them thoroughly before wearing the gloves, after removing the gloves, between patients and before leaving the surgery.
6. Hands should not be washed in a sink which is used for either instrument cleaning or disposal of blood, body substances or chemicals.
7. Always wear gloves when touching mucous membrane, blood, saliva or other potentially infectious material.
8. Gloves should be changed between patients or when they are torn or punctured.
9. Always wear correct gloves for specific procedure to be performed (surgical gloves for surgical procedure, examination gloves for patient examination and heavy duty gloves for cleaning and disinfection). Appropriate gloves in the correct size should be readily accessible.
10. All protective clothing should be removed before leaving the working area.
11. Keep your finger nails short and natural.
12. **Avoiding the sharp injuries**

 This section focus on how to handle those instruments contaminated with body fluid which are sharp and can cut or puncture. The following measures should be followed to prevent sharp injuries (21, 35, 44):

1. When recapping the dental needle put the cap on the working surface pointing away and insert the needle.
2. Pass sharps pointing away from anyone.
3. Avoid picking up sharp instruments by hand (use holders).
4. Use portable needle incinerator if available to burn the dental needle before recapping.
5. Dispose needles and other sharps in the sharp containers which should be at an arm length.
6. Sharp container must be sealed and disposed off when not more than 2/3 full.
7. Use double gloves when doing surgical procedures.
8. Wear sturdy utility gloved when cleaning the instruments to prevent cross- infection.

The cross-infection control regulations should undergo regular monitoring and need

to be subjected to revision whenever necessary.

**Topic 3: Environmental Infection Control**

As a preventive measure against infectious material from the oral health-care environment, and to minimize contamination of surfaces and equipment by the hands of oral health-care workers, protective environmental barriers should be applied on frequently touched areas. Environmental infection Control ensures that there are adequate procedures for the routine care:

1. **Environmental barriers**

Environmental barriers include cleaning and disinfection of environmental surfaces like floors, dental chairs, chair side equipment, and other frequently touched working surfaces in a dental surgery, and ensure that these procedures are being followed. It also includes management of dental waste (disposal). The production of aerosols and spatters during oral health-care procedures, such as while operating high speed dental hand pieces and ultrasonic scalers, has been well documented (45). These aerosols, as well as spatters, have been identified as potentially hazardous, as they may contain infectious agents originating from the patient’s oral cavity or the dental unit waterlines. As a preventive measure against infectious material from the oral health-care environment, and to minimize contamination of surfaces and equipment by the hands of oral health-care workers, protective environmental barriers should be applied on frequently touched areas.

Changing environmental barriers for every patient can be costly and impractical in some clinical environments, such as during screening or orthodontic follow- up appointments. Costs are determined by the number and amount of clinical contact surfaces to be covered, as well as the number of patients treated during a working day (9, 28). The relative risk of exposure, effectiveness of the barrier, time and cost will ultimately determine the choice of protection applied. For example, it was determined that inexpensive food wrap material is an equally effective environmental barrier as some expensive, commercially available, environmental barrier products. However, the effects of environmental barriers on the power output results from dental light-curing units after application, is one area that presents challenges. The physical changes to the output of light-curing tips should be monitored. The thickness and translucency of the barrier may have a negative effect on the curing depth in light-activated resin-composite procedures (46, 47).

1. **Waste disposal**

Waste disposal entails proper disposition of a discarded or discharged materials in accordance with the local environmental guidelines or laws as follows:

1. Each dental surgery must have a dustbin with a cover marked biohazard or disposable color coded refuse bag.
2. All blood contaminated waste should be disposed in red refuse bag.
3. The red refuse bag must be securely sealed.
4. The waste bag should be disposed every day before closing the surgery.

Although mercury in the form of dental amalgam is stable, amalgam should notbe disposed of in the garbage, infectious waste “ red bag,” sharps container or incinerated. Amalgam also should not be rinsed down the drain. Excess amalgam filling material, empty amalgam capsule and extracted tooth with amalgam filling should be collected in a tight bottle or container and handed over to be disposed with other pharmaceutical items. Dental amalgam waste can be recycled to help prevent the release of mercury to the environment. The good news is that amalgam waste, kept separate from other waste, can be safely recycled. The mercury can be recovered from amalgam wastes through a distillation process and reused in new products. Waste generated in oral health-care facilities, including sharps and other infectious waste, is classified as hazardous and poses a serious risk to human health and the general environment (48). Most countries have their own classification of hazardous or health-care risk waste, which often includes infectious waste, pathological waste, sharps, chemical waste and radioactive waste. To reduce the risk of hazardous waste to human health and the general environment, the WHO has defined eight steps to manage health-care waste, including waste minimization, waste generation, waste segregation, intermediate storage, centralized storage, external transport, treatment and disposal (49). By segregating waste, oral health-care facilities can reduce the hazardous waste that requires special treatment and safe disposal. In the UK it was reported that the segregation and disposal of health-care risk waste in oral health-care facilities was carried out according to waste-management guidelines (40). Furthermore, studies from the UK also reported that all orthodontic facilities used ‘yellow bags’ to dispose of clinical waste and had puncture-proof sharps containers, which were in accordance with waste-management recommendations (50).Waste from oral health-care facilities poses an infectious risk. In Brazil, various types of bacterial agents, including *Enterobacter* spp., *Salmonella* spp., *Klebsiella* spp., *Pseudomonas* spp., *Serratia* spp., *Proteus mirabilis*, *Escherichia* spp., *Staphylococcus* spp., *Enterococcus* spp. and *Streptococcus* spp., were detected in waste collected from oral health-care facilities (48). The results are particularly worrying, as the majority of general dentists included (67%) had disposed of hazardous waste, such as syringes, blades and ampoules, in normal dustbins, which were emptied in domestic municipal waste.

**Topic 4: The Disinfection and Sterilization**

Disinfection and sterilization are defined as the physical or chemical processes for destruction or destroying of microorganisms, including pathogens (46). Generally, instruments must be cleaned of debris by scrubbing with soap/detergent and water before disinfection and sterilization.

1. **Disinfection**

Disinfection is a less lethal process than sterilization because it destroys most, but not necessarily all pathogens, for example, it does not destroy bacterial spores (33). Effective use of disinfectants first requires effective dilution of the chemical product and second that the product is applied for an adequate period of contact time, as indicated by the manufacturer (51). These instructions need to be followed meticulously to prevent incorrect use or ineffective application. In different oral health-care facilities, different intra-oral and extra-oral surfaces present different challenges to decontaminate or clean effectively (52). The most difficult surface to clean is textured vinyl , followed by smooth vinyl , enameled metal , service line

rubber hosing and brushed aluminum. In a study in Italy it was demonstrated that, when applying disinfection and cleaning with a sodium - laurylsulphate - based detergent (the wipe–rinse method), the application was cost effective and practical (28). This study also illustrated equivalence with placement of disposable barriers to reduce methicillin - resistant *S. aureus* (MRSA) contamination on dental chairs.

However, findings from the study indicated that routine cleaning, followed by disinfection reduced the microbial load on computer keys by at least 96% (53). Another challenge for cleaning has been identified in orthodontic facilities, where decontamination of photographic retractors, often manufactured from heat-sensitive material, has been reported as being technique sensitive. In a Brazilian study, surface contamination with *S. aureus* was investigated around patients, dental students and in the oral health-care environment (23). By far, the majority of microbial colonies (74%) were obtained from the nose, tongue and hands of patients. The results also clearly indicated that dental students were already contaminated before commencement of the clinical appointment, with the highest colony counts found on gloved hands, followed by the tongue and ungloved hands.

The following are antiseptics which can be used in disinfection where there is no any other means of sterilization of dental instruments.

1. Glutaraldehyde 2% for a minimum of 10 hours.
2. Stabilized hydrogen peroxide 6% for minimum of 6 hours.
3. Ethyl alcohol 70% for surface disinfection (not instruments).
4. Chlorine (sodium hypochlorite 6 %, diluted 10 %) for 10 mints.
5. **Sterilization**

Sterilization is a process of destroying all microorganism and their spores and it is required for all instruments and equipment which will be used during surgical procedure or will come in contact with open wounds or sterile body sites (52). The following are steps on sterilization:

1. All dental surgeries must have an autoclave or sterilizer.
2. Instruments must be cleaned of debris by scrubbing with soap or detergent and water, then put in disinfectant glutaraldehyde.
3. Use heavy duty gloves while cleaning the instruments.
4. Rinse thoroughly with running water and dry the instruments.
5. Wrap the instruments in sterilizing bag and put them in the autoclave following the manufacturer instructions.

Sterilization includes the safe and effective recycling of instruments as a key element of any infection prevention and control program. The Spaulding Classification Scheme is a rational approach to disinfection and sterilization that is used by all health-care professionals as a guide for the decontamination and reprocessing of items (28). The gold standard recommended for sterilization of heat-tolerant instruments or devices is vacuum autoclaving. It is also recommended that dental hand pieces be steam autoclaved (17). Most instruments used in oral health-care facilities today are heat tolerant and can thus be heat sterilized. Application of liquid chemical sterilants is only intended for the processing of heat-sensitive instruments and for instruments with acute cutting edges (54). Effective instrument processing depends on systematic processes, involving a sequence of specific steps.

These processes should ideally be executed in a specific, separate area, designed to promote routine workflow from ‘dirty’ towards ‘clean’ areas (14). During these processes the following should be considered as equally important aspects: occupational health and safety issues, the processing of different instrument types, equipment and supplies, sterilization verification, and stock control (17). Current global recommendations suggest that automated cleaning devices and ultrasonic baths should be utilized to facilitate a thorough cleaning process before sterilization (51). In Germany, however, contradictory results indicated that some dental materials, such as cement, can only be removed manually or with an ultrasonic bath (55). These results thus contrast current regulations as enforced in the UK, where the use of a washer-disinfector is compulsory (17). Various studies have reported on the effectiveness of cleaning, disinfection and sterilization of instruments.

In a study among 30 oral health-care facilities in south-west England, processed instruments, such as matrix bands with retainers, extraction forceps and hand scalers, were investigated (56). The best dental instrument cleaning result was obtained after automated washer-disinfector cleaning. A study in Poland investigated cleaning methods in 43 oral health-care facilities. The results indicated that manual cleaning and ultrasonic baths were applied in more than 50% of the facilities, whilst only 23% used washer-disinfectors (57). Studies on the sterilization methods used for critical instruments have revealed varying results. A Russian study revealed that dental practitioners had a poor understanding of Spaulding’s classification (58). In spite of that, most Russian practitioners indicated that they always pre-packed instruments and applied sterilization for critical instruments. This study also revealed that many practitioners used autoclaves (72%) and dry heat sterilizers (64%), while alcohol is still widely used for disinfection (83%).

Findings from India indicated that many practitioners used autoclaves. However, the results from this study revealed that the majority used locally manufactured pressure cookers for sterilization and thus never packed instruments for sterilization and storage (59). In Turkey, the majority of dental practitioners used dry heat sterilization, although autoclave (47%) and other sterilization methods, such as chemical solutions (35%) and boiling water (2%), were also applied (1).

 A study from Brazil revealed that autoclaves were used by more than 60% of the dental practitioners. However, many practitioners (83%) did not use chemical and biological indicators to verify effective sterilization (41). Similarly, Indian practitioners never used biological indicators to verify sterilizer efficiency (59).

Results from Poland indicated that all sterilization processes were performed in steam autoclaves, and a third verified sterilization using chemical indicators, biological verification was rarely carried out (57). These reports confirm earlier reports from Poland, identifying the need to improve monitoring and documentation of sterilization processes. In Africa and Asia, procedures by traditional healers, including tooth extractions, have been performed for centuries, often without any western technologies, such as radiographs, pharmaceuticals or surgical instruments (60).WHO reports state that more than 80% of some Asian and African countries rely on traditional healers and indigenous knowledge for their primary health care (61). It has been reported that patients prefer treatment by traditional healers because it is inexpensive, and there is a 93% satisfaction rate with the treatment provided (62). It is of concern that many traditional medicine practices have often been adopted in different cultures and regions without international standards or guidelines. Tooth extractions without infection prevention and control could be potentially life-threatening for both oral care workers and patients.

1. **Dental unit waterlines**

The presence of bacteria within the waterlines is conducive to the formation of biofilms, which protect the organisms from desiccation, chemical insult and predation. Moreover, the microorganisms on the surfaces are continuously released from the biofilm into the water flowing through or standing in the tubing lumen, so that biofilm becomes the primary reservoir for continued contamination of the system. The exposing patients or dental teams to contaminated water is not consistent with universally accepted infection-control principles (44). The American Dental Association (ADA) has set a heterotrophic bacteria load of 2.0 x103 cfu / ml for water delivered from dental unit waterlines (63), while the CDC guidelines for Infection Control in Dental Health-Care Settings suggest that the numbers of microorganisms should meet nationally recognized standards for safe drinking water, considering that the standard set for the USA by the Environmental Protection Agency (EPA) is 5.0 x 103 cfu / ml (44). In order to achieve these recommended values, measures for the control of microbial contamination in dental unit waterlines are required, as suggested by various guidelines (17). In the Italian guidelines for the control and prevention of legionellosis (is a respiratory disease caused by bacteria *Legionella* spp.) established by the Italian Health Ministry (64), the dental health care setting is included among health care facilities, suggesting an interactive approach based on a risk assessment plan in order to control *Legionella* spp. contamination. In dental settings the integrated approach to risk management includes a set of technical-practical measures such as waterline flushing, independent water reservoir systems, deionized or sterilized water, inline micro pore filtration, and periodic or continuous chemical disinfection. The need to supply dental unit waterlines with disinfection systems, in order to minimize microbial contamination and biofilm formation, has already been widely discussed (65). The efficacy of different chemical treatments and disinfection protocols, applied both continuously (31, 66, 67) or intermittently (19, 68) has been evaluated for use in dental units. On the basis of these studies and the findings of a recent review (69), the differences observed are not so much linked to the active product used, but rather to the type of protocol applied (continuous or intermittent) and, above all, adherence to disinfection protocols by dental personnel. Biofilm formation in waterlines can be removed by breaking the biofilm into individual bacteria through a cleaning and decontamination process, such as flushing or purging the air- and water lines routinely. Recently, it was found that the primary source of *Legionella* spp. was the water used to supply dental Units (70).

Therefore, the control of *Legionella* spp. in dental health care settings also involves stakeholders other than dental staff. In particular, the domestic water providers should guarantee that the water distributed to the users is free from pathogenic bacteria such as *Legionella* spp.

**Topic 5: Special Considerations**

Special considerations include handling of a dental patient, handling of extracted tooth, sterilization of dental hand pieces and other devices attached to suction lines, dental prostheses, single-use or disposable devices, including saliva ejectors, pre-procedural mouth rinses and dental radiology.

1. **Handling of a dental patient**

A dental patient should alwaysbe attended by an operator (dentist / dental therapist) assisted by the dental assistant. The major source of pathogens in oral health-care facilities is the oral cavities of patients, each laden with high concentrations of oral microbial flora (48, 71). Dental treatments involve lengthy processes hence expose the oral health care workers to the greater risk of contracting airborne infection. In addition, use of standard surgical face masks does not protect against microbial transmission.

1. **Handling of extracted tooth**

Extracted tooth should be handled like other blood contaminated materials and should not be given to the patients routinely. If a patient insists to be given his / her tooth, make sure that it is wrapped well in gauze or any suitable cover to avoid blood contamination (60, 62).

1. **Sterilization of dental hand pieces**

 have focused attention on dental instruments as possible agents for pathogen transmission (3, 6). The American Dental Association recommends that surgical and other instruments that normally penetrate soft tissue or bone (e.g., extraction forceps, scalpel blades, bone chisels and periodontal scalers) be classified as critical devices that should be sterilized after each use or discarded. Instruments not intended to penetrate oral soft tissues or bone (e.g., amalgam condensers, and air or water syringes) but that could contact oral tissues are classified as semi-critical, but sterilization after each use is recommended if the instruments are heat-tolerant (13). If a semi-critical item is heat–sensitive, it should, at a minimum, be processed with high-level disinfection (51, 17). Hand-pieces can be contaminated internally with patient material and should be heat sterilized after each patient. Hand-pieces that cannot be heat sterilized should not be used. Methods of sterilization that can be used for critical or semi-critical dental instruments and materials that are heat-stable include steam under pressure (autoclave), chemical (formaldehyde) vapor, and dry heat (e.g., 180 º C for 2 hours). Dental professionals most commonly use the steam sterilizer (54). All three sterilization procedures can damage some dental instruments, including steam-sterilized hand pieces. Heat-tolerant alternatives are available for most clinical dental applications and are preferred (20).

1. **Dental prostheses**

Dental prostheses or impressions brought into the laboratory can be contaminated with bacteria, viruses, and fungi. Dental prostheses, impressions, orthodontic appliances, and other prosthodontic materials (e.g. temporary prostheses, bite registrations, or extracted teeth) should be thoroughly cleaned of blood and other bio-materials, disinfected with chlorohexidine and thoroughly rinsed before being handled in the laboratory or sent to an off-site laboratory (72). The best time to clean and disinfect impressions, prostheses, or appliances is as soon as possible after removal from the patient’s mouth before drying of blood or other bio-materials can occur (51).

1. **Dental radiology**

Sensors used during digital intra-oral radiography are heat sensitive and cannot be autoclaved. Thus, to prevent cross-contamination, protective barrier envelopes that cover the sensors are used while capturing the radiographs. The sensors, contained inside the plastic barrier envelopes, always remain a potential source of contamination with saliva. Recommendations suggest disinfection of the digital intra-oral radiography sensors and equipment upon removal of the contaminated outer envelope, and the aseptic re-placement of a new protective envelope (51). A Canadian study revealed that contamination of digital sensors can still occur owing to the compromised integrity of the protective envelopes and the techniques applied during placement and removal of the envelopes, despite various precautions to prevent cross-infection (73). An Iranian study indicated significant differences between the bacterial counts on radiographic equipment and surrounding surfaces before and after disinfection. In a comparison of four disinfectant products, Deconex disinfectant (deconex dental BB / ready-to-use disinfecting detergent for dental instruments) demonstrated the highest disinfectant efficacy on radiographic equipment and the surrounding surfaces (74).

**General Conclusions and Recommendations**

The results of the present review showed that cross-infection control topics do not arouse interest among dentists, or that there is a deficiency in continuing dental education on how to avoid cross-infection in dental practice. It appears that the transmission of, and infection with, Hepatitis B virus poses the greatest risk for both patients and the dental team, based on the incidence and risk of transmission.

 that the risk for transmission resulting in an infection with these microorganisms is low. Another important point to keep in mind is that the probability of healthcare-associated infections, particularly in dentistry, of being detected, reported, documented and published in developing countries is rare.

Every member of the team must follow the standard procedures required to prevent the transmission of microorganisms. Besides preventing disease by vaccination, these include hand hygiene, personal barrier protection, instrument disinfection and sterilization protocols, surface decontamination strategies, approaches to maintain the quality of DUWLs, as well as the emergency procedures in case of accidents that would increase the risk of cross-transmission. These procedures substantially lower the risk of the transmission of microorganisms. Every patient should be treated as potentially infectious. The dental team should be acquainted with the biological principles behind these procedures. Improved compliance with recommended infection control measures is required for all dentists. Continuing education programs and short-time courses about cross-infection and infection control procedures are suitable to improve the knowledge of dentists. Also, there is a need to establish the system for amalgam recycling in the country.

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