

Review Article

Infection control protocols in dental clinic

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Abstract

Infection control is an important part of dentistry that helps prevent the transmission of infections from one patient to another and from one dental worker to another. Because dental clinics create a "high risk" environment through the creation of Blood, Saliva and Aerosol, Infection control practices are necessary to protect both Patients and Workers from the hazards of these exposures. In order to protect patient safety and worker safety; strict adherence to Infection control protocols is required. This review article will discuss the reasons why infection control measures should be in place within dental clinics and how they can help to decrease the risk of infection being transmitted to either patients or workers. This review will focus on many aspects of infection prevention which include standard precautions (such as Hand Hygiene), Personal protective equipment (PPE) such as gloves, masks and eye protection, Sterilization and Disinfection of Dental Instruments and Surfaces, Environmental Surface Management (ESM) and Biomedical Waste Disposal (BMD). The Review will give special emphasis to aerosol generation and management due to the fact that high speed dental instruments generate aerosols that may contribute to the transmission of respiratory pathogens. The review will also emphasize the importance of vaccination, occupational safety, and continuing education of all dental healthcare workers in order to implement infection control protocols effectively. Additionally, this review will highlight the recent advancements in infection control technologies (such as improved air filtration systems, automated sterilization monitoring systems, antimicrobial surface materials) that have the potential to improve the safety of all individuals involved in the dental profession. Finally, this review will highlight the need for stronger regulatory frameworks and consistent adherence to national and international guidelines for the continued improvement of infection control in all dental settings. In conclusion, effective infection control is a fundamental aspect of creating a safe dental environment. To achieve this goal, it is necessary to continue to educate ourselves, utilize new technologies, and follow established protocols to minimize the risk of infection and to provide the highest quality of care to our patients.

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1. Introduction

The infection control is an integral part of a safe and effective dental practice. The dental clinic is an environment in which patients and healthcare professionals are continually exposed to saliva, blood and various types of potentially infectious biological fluid.¹ The potential infectious biological fluids present in these environments can contain many different pathogens (bacteria, viruses, fungi) that can be transmitted to patients and healthcare professionals via direct contact, indirect contact, aerosol or contaminated instrument. Thus, strict infection control protocols must be implemented to minimize the possibility of cross-

contamination and protect both patients and dental healthcare workers from infection.²

Many dental procedures require the use of high-speed hand pieces, ultrasonic scalers and air-water syringe units which produce aerosols and splatters. The aerosols produced during these dental procedures can remain suspended in the air for long periods of time and provide a mechanism for airborne transmission of infectious diseases.³ A variety of pathogens can be found in dental environments (hepatitis B, hepatitis C, HIV, tuberculosis, etc.) and can be transmitted to patients and healthcare workers if proper infection control techniques are not used. The recent appearance of COVID-19 has further demonstrated the necessity of having and implementing strong infection control policies in dentistry.⁴

Standard precautions in dental clinics are developed to interrupt the "chain of infection" by either removing or minimizing the amount of microorganisms in the environment. To accomplish this goal, standard precautions include combinations of sterilization/disinfection procedures, personal protective equipment (PPE), environmental surface management, hand hygiene, and proper waste disposal. Standard precautions assume that all patients have the potential to harbor infectious agents whether they are healthy, medically compromised, or asymptomatic. Consequently, each dental provider must implement protective measures each time they interact with a patient.⁵ Proper hand washing or the utilization of an alcohol-based hand sanitizer before and after interacting with a patient is one of the easiest and most successful ways to prevent the transmission of infections in all health care settings. The use of personal protective equipment (such as gloves, masks, protective eye wear, face shields, and gowns) provides a physical barrier between a patient's infectious agent(s) and a dental provider's skin, thus preventing a potential route of transmission. Protective equipment does not only protect the dental provider from acquiring an infection, it also minimizes the risk of transmitting an infection from one patient to another.⁶ Proper cleaning, disinfection and sterilization of dental instruments and equipment is another key component of infection control. Any instrument that comes into contact with blood or tissue must be properly sterilized by using validated methods such as autoclave to remove all microorganisms, including spore-forming bacteria.⁷ Environmental surfaces in the operatory area of the dental office must be cleaned and disinfected at regular intervals to prevent indirect transmission of pathogens. Finally, dental offices must manage biologic waste (including sharp waste and

contaminated items) according to established guidelines to minimize the risk of injury to dental providers and contamination of the environment. A number of national and international agencies have developed comprehensive guidelines to promote standardized infection control practices in dental settings.⁸ These guidelines emphasize the need for training, monitoring and ongoing quality improvement in infection control programs.⁹ Dental providers must adhere to these guidelines to maintain a level of professionalism and to deliver optimal care to their patients.¹⁰ In summary, infection control protocols are essential components of modern dental practice because they decrease the likelihood of disease transmission and protect the health of both patients and dental personnel. Dental providers must continue to follow evidence-based infection control practices and receive education and awareness about infection control issues to create a safe clinical environment and deliver high quality dental care.

2. Review

2.1. Chain of infection in dental settings

Developing an understanding of how a "chain of infection" works, is critical to developing a successful infection control program in a dental clinic. The chain of infection has 6 elements: the source (the infectious agent), reservoir (where the infectious agent resides), portal of exit (how the infectious agent leaves its reservoir), the method of transmission (how the infectious agent is spread from one individual to another), portal of entry (how the infectious agent enters another individuals body), and the susceptible host (an individual who is capable of becoming infected). Microorganisms that are found in the mouths of patients include bacteria, viruses and fungi. Saliva, blood and dental plaque are examples of potential reservoirs where these pathogens may reside.¹¹ They may be transmitted to dental staff by contact with infected tissue, contact with an instrument contaminated with these pathogens, or by inhaling aerosolized pathogens produced when dental procedures produce aerosolized pathogens. By breaking at least one link in the chain of infection by using proper infection control methods, there will be a decrease in the amount of risk of transmitting disease among clinical staff.¹² (Table 1)

Table 1: Table showing chain of infection in dentistry

Component of Chain of Infection	Description	Example in Dental Settings
Infectious Agent (Source)	The microorganism responsible for causing infection.	Bacteria, viruses, and fungi present in the oral cavity of patients.
Reservoir	The place where the infectious agent normally lives and multiplies.	Saliva, blood, dental plaque, contaminated instruments, and dental unit waterlines.
Portal of Exit	The pathway through which the infectious agent leaves the reservoir.	Blood, saliva, respiratory secretions, or aerosols generated during dental procedures.
Mode of Transmission	The method through which the pathogen spreads from one individual to another.	Direct contact with infected tissues, indirect contact through contaminated instruments, or inhalation of aerosols produced during dental procedures.
Portal of Entry	The route through which the pathogen enters the body of a new host.	Mucous membranes, open wounds, respiratory tract, or broken skin.
Susceptible Host	An individual who is vulnerable to infection due to lack of immunity or other risk factors.	Dental healthcare workers, patients with compromised immunity, or individuals with underlying medical conditions.

2.2. Standard precautions in dentistry

Standard precautions for infection control are a fundamental element of infection control methods within dental offices. They assume that every patient has the potential to harbor an infectious agent regardless of their medical condition. Infection control measures with standard precautions include hand hygiene, using PPE, safe sharp handling, respiratory hygiene and clean/sterilized instrument management. By employing these infection control measures consistently you will protect yourself from infection caused by viruses like HIV, Hepatitis B and C and all other BBPs.¹³

2.3. Hand hygiene

Hand washing is generally recognized as the single most important infection prevention technique in hospitals, therefore it is essential that dental hygienists practice hand washing techniques prior to and after each patient contact, after any surface has been touched that may have come into contact with blood or other body fluids, and after the removal of latex gloves.¹⁴ Washing your hands using soap and water for a minimum of 20 seconds will remove all visible debris and kill the majority of microbes present on the skin. Alcohols-based hand rubs (HBHR) can be used in addition to hand washing for non-soiled hands because HBHR's work quickly to eliminate many of the pathogens found on the skin. The regular use of proper hand hygiene procedures will dramatically reduce the risk of cross contamination occurring within your dental office.¹⁵

2.4. Personal protective equipment (PPE)

The primary role of personal protective equipment (PPE) is to act as a barrier between the patient and the dentist or other dental health care provider, to isolate the patient from the potential source of transmission of disease. PPE commonly utilized in the dental setting include; gloves, surgical mask, protective eye wear, face shields, gown and head cover.¹⁶ The gloves serve as a physical barrier that prevents direct contact with the patients blood or saliva. The face shield and/or surgical mask provides a barrier that protects the wearer from inhaling an aerosolized infectious agent when it is generated by either spraying saliva or other oral fluids during a procedure, as well as splattering that may occur during certain procedures. The protective eye wear serves to protect the wearer's eyes from receiving a potentially contaminated drop of saliva or blood. In addition to proper usage of PPE, appropriate selection of PPE, disposal of PPE and maintenance of PPE will be important to maintain a successful infection control program in a dental clinic.¹⁷ (Table 2)

2.5. Sterilization and disinfection of dental instruments

Sterilization is an important part of Infection Control, because many dental instruments come in contact with blood and oral tissues during treatment. Sterilization of dental instruments can be categorized by how much they may contact tissue (tissue-contacting) as critical, semicritical, and noncritical.¹⁸ Critical (surgical, periodontal) items have to be sterilized via a method that will kill all microorganisms; i.e., steam autoclaving.

Semicritical items need to be high level disinfected or sterilized. Non-critical items are simply cleaned and disinfected by an intermediate or low-level disinfectant. The total process of instrument care begins with cleaning, continues with packaging, then sterilization, and finally storage.¹⁹

2.6. Environmental surface disinfection

Surface areas within the dental operatory (i.e., chairs, countertops, radiographic equipment) that come into contact with patients are subject to potential microbial contamination during each patient visit. Cleaning and disinfecting these areas are essential for preventing indirect transfer of disease-causing organisms (pathogens). In addition to cleaning and disinfecting the surface areas, barrier methods (such as plastic wraps and disposable covers) can be placed over the surface area to further limit the potential for microbial contamination. Disinfectants utilized in the dental environment must

have a broad-spectrum activity and must be utilized per the manufacturer's recommendations.²⁰ (Table 3)

2.7. Aerosol and airborne infection control

Aerosols are created when dental treatment is performed; these can contain bacteria and other pathogens that are present in a patient's mouth. Aerosols are airborne and can stay suspended in the air; they may potentially be transferred to patients by an infected healthcare worker or by coming into contact with surfaces contaminated by the aerosol. There are several methods to reduce aerosol contamination during dental treatment including the use of a high-volume evacuation system, a rubber dam, a pre-procedure rinse, and proper ventilation systems. Due to the emergence of numerous respiratory infections, aerosol transmission is receiving increased attention as it underscores the necessity for enhanced infection control measures at the clinical level.²¹

Table 2: Table showing types and functions of personal protective equipment

Type of PPE	Purpose	Protection Provided in Dental Settings
Gloves	Provide a physical barrier between the dental professional and the patient.	Prevent direct contact with blood, saliva, and other potentially infectious materials.
Surgical Mask	Protect the respiratory tract of the dental healthcare worker.	Prevent inhalation of aerosolized infectious agents and splatter produced during dental procedures.
Protective Eyewear	Shield the eyes from contamination.	Protect eyes from droplets or splashes of saliva, blood, or other oral fluids.
Face Shield	Provide full-face protection during procedures.	Protect the face, nose, mouth, and eyes from aerosols and splatter generated during dental treatments.
Gown	Protect skin and clothing from contamination.	Prevent exposure to infectious materials during dental procedures.
Head Cover	Minimize contamination of hair and scalp.	Protect hair from aerosolized particles and splatter.

Table 3: Table showing environmental surface disinfection methods in dental clinics

Environmental Surface	Potential Risk	Infection Control Method
Dental chair	Contamination from patient contact, saliva, and aerosols during procedures.	Regular cleaning and disinfection after each patient; use of disposable barrier covers.
Countertops and work surfaces	Indirect contamination from instruments, gloves, and dental materials.	Surface cleaning with approved disinfectants and use of protective barriers.
Radiographic equipment	Contact with contaminated gloves and patient saliva during imaging procedures.	Disinfection between patients and use of disposable plastic barriers.
Clinical contact surfaces	Exposure to splatter and aerosolized microorganisms.	Application of broad-spectrum disinfectants according to manufacturer guidelines.
Barrier protection (Plastic wraps, disposable covers)	Prevents direct contamination of frequently touched surfaces.	Replace barriers after each patient to minimize microbial contamination.

2.8. Biomedical waste management

Biomedical waste management is a key factor in the prevention of contamination of the environment as well as preventing occupational hazards for workers involved with the waste generated by dental clinics. A variety of waste is generated by dental clinics such as; sharps, contaminated gauze, extracted teeth, disposable PPE, etc. All of this material must be properly segregated, collected and disposed of per biomedical waste management guidelines. Sharps must be disposed of in puncture resistant containers to protect against accidental injury and all other contaminated material must be disposed of in biohazard bags that are correctly labeled.²²

2.9. Vaccination and occupational safety

Vaccination has a significant role in preventing occupational infections for dental healthcare providers. Hepatitis B immunizations are highly recommended for all dental personnel as they have a high likelihood of being exposed to bloodborne pathogens through their work. Providing regular training programs, educating on infection control and monitoring compliance with protocols also helps maintain a healthy working environment for dental healthcare providers.²³

2.10. Importance of training and monitoring

Continuous education for all members of a dental team is required to continue to follow current infection control guidelines; therefore continuous education is also required for all members of a dental team as well as updates on recommendations from local and national organizations, emerging infectious diseases, and advancements in sterilization equipment or techniques. Regular monitoring (through audit or review by an

infection control committee) allows for evaluation of the infection control program's effectiveness, provides input for improvement to the infection control program's quality, and ultimately assists in providing a safe environment for both patients and employees in dental clinics.²⁴ (Table 4)

2.11. Color coding of medical wastes

Biomedical waste in healthcare settings is segregated using a standardized color-coding system to ensure safe handling, transport, and disposal, thereby reducing infection risk and environmental contamination. In dental clinics, this is a critical component of infection control protocols.

- 1. Yellow bag/container: Used for infectious waste such as human tissues, body parts, blood-soaked materials, extracted teeth, and contaminated dressings. Disposal method includes incineration or deep burial.
- 2. Red bag/container: Used for contaminated recyclable waste like tubing, IV sets, catheters, gloves, and plastic items. These are treated by autoclaving or chemical disinfection and then recycled.
- 3. White (translucent, puncture-proof container): Used for sharps such as needles, scalpels, and blades. These require sterilization followed by shredding or encapsulation.
- 4. Blue container: Used for glassware such as broken vials, ampoules, and metallic implants. These are disinfected and recycled.

Proper segregation at the source minimizes occupational hazards and prevents cross-contamination in clinical settings.

Table 4: Table showing training and monitoring in dental infection control programs

Aspect	Description	Importance in Dental Clinics
Continuous Education	Ongoing training for dental team members regarding infection control practices.	Ensures that dental staff remain updated with current infection control guidelines.
Updates on Guidelines	Learning about new recommendations from local and national health organizations.	Helps in implementing standardized and evidence-based infection control practices.
Awareness of Emerging Diseases	Education regarding newly emerging infectious diseases and their transmission risks.	Enables dental professionals to adapt infection control measures accordingly.
Advancements in Sterilization Techniques	Training on new sterilization equipment and improved decontamination methods.	Improves the effectiveness and reliability of infection prevention strategies.

Table 4 Continued....

Monitoring and Auditing	Regular evaluation of infection control practices through audits or infection control committees.	Assesses the effectiveness of protocols and identifies areas for improvement.
Quality Improvement	Continuous review and modification of infection control programs.	Ensures a safer environment for both patients and dental healthcare workers.

2.12. Herpetic whitlow

Herpetic whitlow is a painful viral infection of the fingers caused by the Herpes Simplex Virus (HSV-1 or HSV-2), commonly seen in healthcare workers, including dentists, due to exposure to infected oral secretions.

1. **Etiology:** Direct inoculation of HSV through broken skin or cuts.
2. **Clinical features:**
 - Painful swelling of the finger
 - Formation of clear vesicles that may coalesce
 - Erythema and tenderness
 - Possible fever and lymphadenopathy
3. **Diagnosis:** Usually clinical; confirmed by viral culture or PCR if needed.
4. **Management:**
 - Antiviral therapy (Acyclovir)
 - Analgesics for pain relief
 - Avoid incision and drainage (contraindicated as it may spread infection)
5. **Prevention:** Use of gloves, proper hand hygiene, and avoiding direct contact with lesions.

Herpetic whitlow is important in dental practice as it represents an occupational hazard, emphasizing the need for strict infection control measures.

3. Discussion

The evolution of infection control in dental offices has undergone many changes since the late 20th century, with the advent of enhanced sterilization methods, improved personal protective equipment (PPE) and increased regulation.²⁵ As the world continues to evolve with emerging pathogens and new disease entities, it will continue to require a proactive approach to infection control by continuously updating and improving infection control protocols. Therefore, contemporary dental practice will need to incorporate new technologies, new and updated guidelines and better clinical methods to protect the patient and the clinician.

A major area for development is aerosol management in dental settings. Most dental treatments produce aerosol via high-speed hand pieces, ultrasonic scaling devices, and air/water syringe devices, which may carry microorganisms responsible for the transmission of

respiratory infections.²⁶ While high volume evacuators and rubber dams are being used in an effort to minimize aerosol dissemination, there is a growing need for more effective aerosol containment methods. Advanced air purifiers using HEPA filters, UVGI, and negative pressure ventilation systems may reduce the amount of microbes present in dental operatory environments. Therefore, improved ventilation design in dental offices needs to become a standard in the near future.²⁷

Another significant development is the incorporation of digital/automated monitoring systems for sterilization. Autoclave usage is common in the sterilization of dental instruments; however, mistakes in the sterilization process may occur due to improper loading, insufficiencies in the sterilization cycles, or lack of monitoring. In the future, emphasis should be placed upon utilizing automated sterilization tracking systems that document all sterilization parameters digitally, i.e., temperature, pressure, and cycle time. This will assist in providing consistent sterilization results and provide evidence for quality assurance and regulatory compliance.²⁸

Research and development of antimicrobial materials/surfaces to enhance infection control in dental offices is another area that holds much promise. Presently, conventional dental equipment and surface areas often harbor microorganisms if they are not thoroughly disinfected. Research into antimicrobial coated dental chair surfaces, instrument tray surfaces and other frequently contacted surfaces may aid in reducing microbial contamination between patient appointments. Also, research into antimicrobial dental unit waterline technologies may help eliminate biofilm growth and improve the quality of water used for dental procedures.²⁹

Additionally, innovation in personal protective equipment (PPE) is needed to increase both the effectiveness of PPE and the comfort level of dental professionals. Current PPE, such as masks, gloves, gowns and face shields, effectively reduces exposure to infectious materials; however, prolonged wear can result in discomfort, decreased visual acuity and communication barriers. Future PPE products should be

lightweight, breathable, reusable and have improved filtration characteristics. Future innovations in PPE may include smart PPE with built-in sensors that detect contamination or monitor exposure to aerosolized infectious agents.³⁰

Another area that necessitates improvement is infection control training and monitoring compliance among dental healthcare providers. Although, national and international guidelines are available for infection control, the degree to which dental professionals adhere to infection control protocols varies greatly. Mandatory continuing education courses, simulation based training and mandatory certification in infection control practices would likely contribute to increasing compliance. In addition, clinics may utilize digital audit systems and real-time monitoring systems to evaluate whether their staff members adhere to proper hygiene protocols and identify areas where improvement is necessary.³¹

Use of artificial intelligence (AI) and digital technologies may revolutionize infection control practices in dentistry. AI based systems may evaluate sterilization processes, assess the potential for infection risk within dental environments, and provide alert notifications when protocol violations occur. Patient screening systems that use digital technology may be utilized to screen patients prior to treatment, enabling clinics to take additional precautions with patients who have infectious diseases.³²

In addition to the use of technological advancements, regulatory frameworks and standardized global guidelines are required to assure uniformity in infection control practices throughout dental offices worldwide. Developing countries face numerous challenges, including resource limitations, inadequate facility infrastructure, and lack of training. Professional organizations and governments must collaborate to create policies, provide funding for infection control infrastructure and schedule regular inspections of dental facilities.

Ultimately, the experiences gained during global health crises has highlighted the necessity of preparedness for emerging infectious diseases. Dental offices must establish flexible infection control protocols that can be quickly implemented during outbreaks and pandemics. Preparedness plans, inventory of essential PPE, and emergency infection control strategies will be vital in maintaining safe dental service delivery during future public health crises.³³

In summary, although the infection control protocols of today have significantly improved safety in dental care,

continued advancements in technology, infrastructure, education, and regulations are necessary to continually address the evolving threats of infectious diseases. The integration of state-of-the-art technologies, comprehensive educational programs, and strong regulatory support will be pivotal in enhancing infection prevention practices and creating a safer environment for dental health care delivery.

4. Conclusion

Dental clinic infection control policies are vital for patient safety and for reducing the potential for the spread of infectious disease among dental health professionals. Dental health professionals frequently expose themselves to their patients' blood, saliva, and aerosols produced through many dental procedures; therefore, it is critical that they follow all established infection control principles to protect their patients and themselves. Infection control is important for protecting the patients and staff members in dental clinics because standard precautions such as proper hand washing, the use of personal protective equipment, sterilizing or disinfecting of dental instruments, cleaning of environmental surfaces, and safe handling of biomedical waste are an integral part of limiting the potential for cross contamination in dental offices.

As technology advances in dentistry, along with our knowledge of how infections are transmitted, we are able to implement new and improved ways to limit the opportunity for infection transmission in dental offices. However, new infectious agents continue to emerge and the way we practice dentistry continues to evolve, so we cannot stop improving and adapting our methods for controlling infection in dental clinics. Better aerosol control systems, enhanced sterilization monitoring systems, antimicrobial surfaces, and better ventilation systems could help improve our infection prevention techniques in dental clinics.

Furthermore, continued education on infection control, monitoring compliance with established guidelines, and adhering to national and international guidelines are necessary for providing the highest quality of infection control in dental clinics. Therefore, by incorporating new technology into infection control education, increasing compliance with established infection control principles, and practicing strict adherence to established infection control principles, we can create a safer clinical setting for our patients and ourselves, and provide the highest quality dental care possible with minimal risk for infection transmission.

Author Contributions

Ajmol Theresa Jose: Conceptualization, literature review, and original draft preparation. Noor Wahida Ismail-Suhaimy: Literature review and manuscript editing. Shiprita Kumari: Literature search and manuscript preparation. Saurabh Shekhar: Scientific review and manuscript revision. Deepti Krishnan Kutty: Critical review and supervision. Krishna Priya Balachandran: Supervision, final review, and approval of the manuscript. All authors read and approved the final manuscript.

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