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Pathogens associated with contamination in dental clinics: Evaluating emerging threats with a focus on mpox

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INTRODUCTION

The presence of various pathogenic agents in healthcare settings, especially dental clinics, presents significant challenges for infection control and patient safety. This review explores the diverse range of pathogens associated with dental surface contamination, including well-established pathogens and the recently reported monkeypox (mpox) outbreak.

Aims and objectives

The primary aim of this review is to offer a comprehensive overview of the existing literature on pathogens linked to surface contamination in the dental environment. The objectives are to:

1. Examine the transmission dynamics of various pathogens in dental clinics.
2. Assess the role of saliva in microbial dispersion and the impact of dental procedures on the aerosolisation of viruses, bacteria and fungi.
3. Evaluate environmental contamination risks associated with these pathogens.

Methods

The review involves an analysis of existing studies that examine the presence and transmission of pathogens in dental settings. It includes a detailed examination of the characteristics of viruses, bacteria, fungi and the impact of aerosol-generating procedures on the spread of these microorganisms.

Results

The review highlights the significant risks posed by surface contamination in dental clinics, particularly in relation to the aerosolisation of pathogens during dental procedures. It synthesises data showing that dental environments can become reservoirs for pathogens, contributing to nosocomial infections.

Conclusions

This review underscores the need for updated guidelines and enhanced surveillance to address the risks associated with surface contamination in dental clinics.

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The author declares there is no conflict of interest.

Pathogen transmission

The transmission of pathogens in dental clinics poses a significant risk to both patients and healthcare professionals, especially during aerosol-generating procedures (AGPs). The close proximity required for dental treatments, in addition to the frequent use of high-speed instruments, facilitates the spread of infectious agents through aerosols and surface contamination. While established pathogens such as bacteria, viruses and fungi have long been recognised as possible sources of nosocomial infections, the recent emergence of novel threats such as monkeypox,[1] now referred to as mpox, highlights the need for updated infection control protocols and enhanced vigilance in dental practices.[2-4]

Role of saliva in surface contamination

Saliva plays a pivotal role in maintaining oral homeostasis and harbours essential biological constituents necessary for oral health and acts as a reservoir for microorganisms.[5-7] Saliva contributes to the immune defence against bacterial, fungal and viral infections. In doing so, it maintains the integrity of both hard and soft tissue. This diverse microbiota can include both beneficial and pathogenic microorganisms. The composition of the oral microbiota within saliva is influenced by various factors such as dietary habits, smoking, age, oral hygiene practices, dietary practices and systemic conditions.[8-10] The presence of these microorganisms and the interactions among each other has a pivotal role in maintaining oral health. Under certain circumstances the change in the equilibrium within the oral cavity can result in the development of oral diseases that may result in contamination when aerosolised. Dental healthcare workers face occupational health risks due to their close proximity to the oral cavity and exposure to aerosols generated during procedures.[7,11,12]

Aerosol formation

During AGPs aerosols is formed primarily due to the large volume of water that is necessary to prevent trauma or damage to the tooth structure during dental procedures. As a result of the mechanical contact between the instrument and the tooth, saliva, biological tissue or blood, aerosolised

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particles of varying sizes are formed.[12,13] Aerosol particles contaminated with biological matter such as bacteria, viruses or fungi are known as bioaerosols.[11] AGPs using high speed dental instrumentation are the principal source of bioaerosols, as indicated by the elevated particle concentrations during the dental procedures in comparison to baseline assessments of air contamination.[11,12,14] AGPs are especially concerning because it results in aerosols small enough (less than 5 microns) to remain suspended in the air for extended periods, increasing the potential risk for inhalation by dental staff, patients and the subsequent deposition on surfaces. The pathogens carried within these aerosols can contribute to the transmission of infectious diseases, including respiratory infections, which are a major concern in dental settings.

Other sources of contamination are as a result of ultrasonic scalers and water syringes that can result in varying amounts of aerosols produced and dispersed into the environment.[11,12,14] Ultrasonic instrumentation contribute to the production of aerosols by means of the high-frequency vibrations on dental plaque or calculus buildup.[11] The airway syringe used for irrigating and drying during dental procedures is another contributor to the production of aerosols, where the compressed air interacts with water or saliva which results in the spread of microorganisms present in the oral cavity.[12] An additional source of contamination is the dental unit water line (DUWL). DUWL can carry low levels of microbial pathogens that can develop biofilms and can become a source of contamination during dental procedures.[15]

The production and composition of bioaerosols in dental settings is influenced by various factors that are associated with the dental procedure being performed and the patient.[12,13] The patient factor in the composition of bioaerosols is influenced by saliva, intra-oral infections, biological matter, blood, and infective agents from the respiratory system.[11] Patients with compromised immune systems or those who are actively infected have an increased chance of spreading pathogens by coughing, talking and sneezing.[16] Saliva and blood from patients contain a wide range of microorganisms, including viruses, bacteria and prions.[11,16] Recent public health challenges, such as the Coronavirus Disease 2019 (Covid-19) pandemic and the emergence of mpox, have underscored the importance of understanding and mitigating the risks associated with bioaerosols.

Rafiee et al, 2022 suggested that contrary to other reports, patients' nasal and salivary fluids are not the primary sources of bioaerosols in dentistry and, while it does contribute to the overall microbial load in the dental settings, their contribution is comparatively insignificant when compared to AGP using ultrasonic scalers or high-speed drills.[12,14,17] This claim is, however, not supported by the available studies that support the theory that saliva contamination results in exposure to pathogenic microorganisms. In the case of Covid-19, it can spread through respiratory droplets and saliva.[11] This is usually directly from a symptomatic or asymptomatic patient or indirectly from contaminated surfaces. The virus can also spread through aerosols generated during certain dental procedures, posing a significant risk in the dental setting.[8,12,18,19] It is important to note that saliva contains a wide range of microorganisms and can increase the risk of transmission by contamination through either aerosolised form, direct contact or a secondary surface contamination.[20]

Aerosolised saliva can contaminate surfaces, instruments and personal protective equipment (PPE), leading to the potential spread of infections within dental clinics. The risk of contamination is particularly high in enclosed spaces where ventilation may be limited.[17,21] Variables such as ventilation through open windows, doors or air conditioning can affect the distribution and spread of bioaerosols, leading to variations in contamination.[11,16,17]

The possible routes for infection transfer in a dental clinic as described by the World Health Organisation (2020) are: direct droplet spread, indirect contact spread and airborne spread.[22] Direct droplet spread occurs when respiratory droplets or aerosols of an infected individual come into contact with mucous

Table I: This table categorises various microorganisms commonly found in the dental clinic, detailing key characteristics and potential health risks.

Category	Microorganism	Characteristics
Viruses	Hepatitis B Virus (HBV)	Causes hepatitis; spread through blood and bodily fluids
	Hepatitis C Virus (HCV)	Similar to HBV; leads to chronic liver disease
	Human Immunodeficiency Virus (HIV)	Attacks the immune system
	Herpes Simplex Virus (HSV)	Causes cold sores
	Human Papillomavirus (HPV)	Associated with warts and certain cancers
	Varicella Zoster Virus (VZV)	Causes chickenpox and shingles
	Influenza A (H1N1)	Can result in respiratory illness, including pneumonia or respiratory failure
Bacteria	Staphylococcus aureus	Known for skin infections; resistant strains (MRSA) exist
	Streptococcus mutans	Linked to dental caries and plaque formation
	Streptococcus pyogenes	Causes throat infections and other complications
	Pseudomonas aeruginosa	Opportunistic pathogen; resistant to many antibiotics
	Legionella pneumophila	Causes Legionnaires' disease; found in water sources
	Mycobacterium	Causes respiratory infections; linked to DUWLs
Fungi	Candida albicans	Common in oral cavity; can cause thrush
	Aspergillus spp.	Associated with respiratory issues and allergies
	Penicillium spp.	Can cause respiratory issues and allergies
	Cladosporium spp.	Common allergen; associated with asthma
	Alternaria spp.	Another common allergen; found in damp environments

[8,12,15,26-34]

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membranes of a new host.[12,21] Indirect contact spread is caused by cross-contamination or incorrect hand hygiene and transfer from contaminated surfaces or instrumentation.[11] Airborne spread refers to the transmission of pathogens through aerosols inhaled by patients or dental staff.[20,21,23]

Identifying the specific pathogens associated with bioaerosol contamination allows dental professionals to assess the risk to patients and staff. Certain pathogens are classified more hazardous or transmissible than others and require specific disinfectants.[24] In addition, some pathogens are able to survive on certain substrates and measures can be taken to isolate and eliminate the source, reducing the risk of wider contamination.[25]

Pathogen survival and transmission risks in dental settings

Among the viral pathogens, the most significant and common are those that can be transmitted through blood and bodily fluids, such as Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), Hepatitis B Virus (HBV), Hepatitis C Virus (HCV) and Human Immunodeficiency Virus (HIV). Human Papillomavirus (HPV) and Varicella Zoster Virus (VZV) are also potential contaminants, with the transmission occurring during contact with infected bodily fluids or aerosolised particles.[12,28,34,35]

Bacterial contamination in dental environments is equally concerning and include Staphylococcus aureus, including methicillin-resistant strains (MRSA), which is a common pathogen, often associated with skin infections. Streptococcus mutans, commonly found in the oral cavity, are linked to dental caries.[29] Opportunistic pathogens such as Pseudomonas aeruginosa and Legionella pneumophilia are commonly found in dental water lines, potentially leading to respiratory issues.[36] Oral microorganisms such as Micrococcus spp. and Corynebacterium spp. are also found in aerosols, indicating the presence of bacteria originating from the oral cavity.[30] A common bacterium *E. faecalis* is a resilient pathogen, particularly in dental environments. It is frequently associated with root canal infections and is known for its resistance to treatment and poses a significant risk for contamination due to its ability to survive harsh conditions.

Fungal pathogens such as *C. albicans,* aspergillus spp., Penicillium spp., Cladosporium spp. and Alternaria spp. have been reported to have contaminated dental settings. These fungi are often associated with immunocompromised patients.[37] The ability of these microorganisms to remain on flat and non-flat surfaces, as well as their presence in aerosols, increases the risk of spread of potentially harmful pathogens including antibiotic resistant strains such as MRSA.[32]
Studies have provided evidence that different pathogens can survive on environmental surfaces and pose a health risk – for example, the influenza virus can survive on surfaces for up to 48 hours, while *Mycobacterium tuberculosis* bacteria can survive on surfaces for up to four months.[12] Holiday et al 2020 reported that SARS- CoV-2 may remain viable and infectious in aerosols for several hours and on surfaces for several days.[21,26,30] In the study by Van Doremalen et al. (2020); SARS-CoV-2 and SARS-CoV-1 can remain viable on environmental surfaces consisting of: plastic, wood, copper, stainless steel, cardboard, cloth and the outer layer of surgical masks.[38] The study concluded that the SARS-CoV-2 virus was more stable on plastic and stainless steel (up to 72 hours) than in copper (up to 4 hours) and cardboard (up to 24 hours). In addition, SARS-CoV-2 virus remained viable in aerosols throughout the duration of the experiment (3 hours).[38] The H1N1 influenza virus can survive on surfaces in a dental clinic for a few hours to up to two days, depending on environmental conditions such as temperature and humidity. The virus tends to survive longer on non-porous surfaces such as stainless steel or plastic than on porous materials such as fabric. Mpox virus can survive on surfaces for several days to weeks, particularly in cool, dry environments, and on porous materials such as bedding and clothing, making thorough disinfection crucial to prevent transmission.

Atmospheric conditions such as temperature and relative humidity can influence the endurance of aerosolised viruses with low humidity levels prolonging viral survival.[12,24,28,34] A primary consideration when selecting a disinfectant that is effective against any microorganism is its ability to penetrate.[39] Several of the aforementioned pathogens have the ability to form biofilms. Biofilms are protective matrixes that inhibit the penetration of a disinfectant and can often result in an increased risk of contamination and resistance development.[32,35] The presence of antibiotic-resistant pathogens poses a significant concern, with the potential for nosocomial infections, and highlights the need for improved infection prevention and control measures.[40]. Murakami and Fujii (2018) confirmed the likelihood of drug-resistant bacteria MRSA colonising the oral cavity and by default be associated with surface contamination in dental clinics because of the nature of the profession.[40,41] Additionally, understanding the survival times of these pathogens on various surfaces and within aerosols helps inform infection control strategies, leading to safer dental spaces.

While the virulence of pathogens enhances their ability to infect susceptible hosts, another factor is the routes in which infections can be transmitted. The most obvious source of these pathogens associated with contamination is saliva from the patient's oral cavity.[24] In addition to the study of commensal pathogens associated with the oral cavity the Covid-19 pandemic resulted in a burst of investigations notably in relation to how infections are transferred from one host to another.[37,42-44]

Saliva-related risks in dental practice amid Covid-19

Management of saliva contamination during the Covid-19 pandemic was of utmost importance especially in light of the ability of the virus to spread via saliva.[18,45] The article by Chopoorian et al (2023) outlines the pathways for Covid-19 to be present in saliva.[45] Direct exchange of secretions from the upper and lower respiratory tract and the oral cavity, the presence of the virus was noted in gingival crevicular fluid, which is rich in blood components and can contribute viruses to saliva.[46]

The salivary glands are a potential source of the virus, as epithelial cells of salivary gland ducts are early targets for Covid-19 infections.[19,46] Lastly, the posterior oropharyngeal saliva samples from Covid-19 positive patients can remain serially positive for viral load for up to 25 days from the onset of symptoms. This prolonged viral shedding in saliva highlights the potential for transmission of Covid-19 even in individuals who may not exhibit symptoms.[46] Gaudin et al (2020) and Patel (2020) reported that saliva contamination is a significant source of SARS CoV-2 transmission due to its presence in aerosols created during dental procedures and SARS-CoV-2 was detected in saliva samples from 87%-100% of clinical

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patients.[19,54,46] These studies on how Covid-19 is transferred and its presence in aerosols refutes the report by Rafiee et al (2022) that stated salivary and nasopharyngeal secretions are negatable. This information is of critical importance in understanding and managing saliva contamination in dental clinics and to mitigate the risk of Covid-19 transmission via aerosol contamination.[47]

As previously described bioaerosols can contain a multitude of microorganisms that can contaminate various surfaces in dental clinics, including countertops, dental chairs and handpieces with biofilm producing bacteria, which increases the risk of cross contamination.[31,48,40] This is supported by the study by Liu et al (2023) that reported biofilms can adhere to living or abiotic (non-living) surfaces, which might include surfaces in the medical environment.[50] Biofilms formed from saliva-contaminated surfaces may harbour pathogenic bacteria, fungi or viruses increasing the risk of infection transmission between patients and dental healthcare workers.[50]

Mpox: A critical concern for healthcare professionals in dental settings

Amid recent developments, mpox has become a critical concern for healthcare professionals due to its transmission from animals to humans. Human monkeypox, now referred to as mpox, was first identified in 1970 in the Democratic Republic of Congo[1,53]. Mpox is a viral zoonotic disease related to smallpox transmitted from animals to humans through a bite or a scratch from infected animals. While endemic to Africa, multiple cases outside of disease endemic countries shows that it has become a significant travel-related disease and all health care workers including dental personnel should be cautious in preventing its spread.[53,54] Human-to-human transmission of mpox is rare but can occur through direct contact with lesion material or respiratory droplets. The main entry sites for mpox are inhalation, open wounds, non-intact skin and mucous membranes.[53,54,55]

The infection spreads through large respiratory droplets and requires prolonged close contact, unlike SARS-CoV-2 infection, which can spread via small droplets. Experimental studies suggest mpox virus can remain infective in aerosols for several hours and may spread via aerosolised particles. The mpox virus primarily infects the following areas of the body:

1. Skin and mucous membranes: Mpox virus often causes skin lesions that begin as macules and vesicles and eventually form scabs. It can also affect mucous membranes, including the oral mucosa, where it presents as macules and vesicles.
2. Lymphatic system: The virus can cause significant swelling in lymph nodes near the site of infection.
3. Respiratory tract: While less common, mpox virus can infect the respiratory tract, as the virus is spread through respiratory droplets. However, the primary mode of transmission is through direct contact with skin lesions or bodily fluids rather than airborne particles.[53,54,55,56]

Initial symptoms often appear in the oral cavity with macular lesions, followed by a characteristic rash. The highly contagious incubation period commonly ranges from 7 to 14 days. The prodromal symptoms last from 2 to 4 days, which is characterised by fever and lymphadenopathy, followed by cutaneous involvement. This is characterised by single to multiple lesions that change from maculae to papules in 12 days. In addition, vesicles and pustules present at various stages.[53,54,55,56]

Oral lesions occur in 70% of cases, presenting as perioral mucocutaneous lesions and vesicles on the oral mucosa and lips which may precede the skin rash. Mpox is a self-limiting disease with very low mortality and may last from 2 to 4 weeks. Although mpox is similar to chickenpox, there are a number of differentiating signs, the main element being lymphadenopathy. Mpox positive individuals are considered contagious during the prodromal or acute phase and even though mpox appears to be a significant travel-related disease in light of recent developments dental healthcare workers should note that initial signs of the disease usually appear on the oral mucosa prior to the characteristic skin lesions.[53,54,55,56]

Based on this characteristic, dental health care providers need to be cognisant of the clinical presentation of the disease but also of the associated preventive measures for infection control in dental settings. Oral screening is recommended in high-risk individuals and in patients with an unexplained rash and one or more symptoms typical of monkeypox.

A differential diagnosis for monkeypox includes varicella-zoster virus infections such as chickenpox and herpes zoster (shingles), though chickenpox lesions are typically not umbilicated, and herpes zoster has a dermatomal distribution. Molluscum contagiosum, another Poxviridae virus, can cause similar raised, pink lesions with central dimples. In cases where oral ulceration is an early symptom, other causes such as traumatic ulceration should be considered, but the presence of systemic symptoms such as fever and lymphadenopathy suggest an infectious cause.[53,54,55,56]

Given the mpox transmission routes, all healthcare workers are at increased risk of infection from close and prolonged contact with patients. Oral healthcare providers may be at additional risk because they have close contact with patients for prolonged periods, and dental procedures may generate infected droplets and aerosols. Infected fluids from perioral or oral lesions containing mpox virus or from saliva and blood can enter the environment through direct contact and droplets. In addition, mpox virus remains infectious in aerosols for several hours. Aerosolisation can be considered an important route of transmission in dental settings, further increasing the risk of occupational exposure for dental personnel and cross-infections in dental settings. As previously mentioned, dentists should be vigilant when examining suspected mpox cases, as primary lesions often start in the oropharynx and oral samples, including saliva, may have the highest viral load, with viral shedding detectable in oropharyngeal secretions before skin lesions develop. Viable mpox virus can be found in oral samples from days 9 to 18. Basic principles of infection control are currently considered able to contain mpox spread.[1,53,54,55,56]

This includes the rapid diagnosis isolation, contact tracing and surveillance during the viral incubation period. In dental clinics, precautions against mpox involve distinguishing it from similar lesions and taking comprehensive infection control measures. The main transmission route involves contact with the lesion, so it is crucial to implement that series of precautions to control standard and contact infections when treating patients with symptoms of mpox.[53,54] Clinicians

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should use standard, contact and droplet precautions, including N95 masks, FFP3 respirators, fluid-resistant attire, and eye protection, especially in isolated treatment areas. Proper hand hygiene, cleaning and disinfecting, and careful handling of materials are essential. In the case of a suspected monkeypox infected patient, the patient should be provided with a surgical mask and asked to return home to isolate and await further advice.[53,55,56] The dental healthcare professional should then contact their local health protection team for guidance.

It is important to note that pre-procedural mouth rinses can mitigate some risks associated with saliva contamination; however, it serves a method to reduce rather than eliminate pathogenic load.[35,51] While both mpox virus and SARS-CoV-2 pose significant risks, their differences in transmission dynamics and clinical management necessitate varied approaches to infection prevention. For instance, while the risk of aerosol transmission in SARS-CoV-2 has led to the widespread adoption of enhanced personal protective equipment (PPE) and air filtration systems, mpox requires additional considerations, such as the handling of contaminated materials and the potential for skin-to-skin contact transmission.[53,54,55] The knowledge and understanding of how infectious agents are transferred for one host to another, biofilm formation and its implications in the dental surgery is an important prerequisite for dental staff. This understanding is central in implementing successful infection control and prevention strategies aimed at combating biofilm formation on dental instruments and environmental surfaces, which encompasses the management of saliva contamination.[46,52]

In conclusion the risk of pathogen transmission in dental clinics encompasses both established and emerging threats. Traditional pathogens such as bacteria, viruses and fungi continue to pose significant risks; however, emerging threats such as monkeypox, with distinct transmission routes and clinical implications, highlight the need for an adaptable approach to infection control. The ongoing evolution of infectious disease threats underscores the necessity for continuous vigilance and the regular updating of infection control protocols. Dental practices must remain proactive in integrating new evidence and guidelines to safeguard both patients and healthcare providers. By staying informed and responsive to emerging threats, dental clinics can better protect their patients and staff from infection and ensure a safer clinical environment.

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The Continuing Professional Development (CPD) section provides for twenty general questions and five ethics questions. The section provides members with a valuable source of CPD points whilst also achieving the objective of CPD, to assure continuing education. The importance of continuing professional development should not be underestimated, it is a career-long obligation for practicing professionals.