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Short notes on **Transmission of infection**

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Background

How do infections occur?
An infection occurs when micro-organisms enter the body, increase in number, and cause a reaction of the body. **Three things are necessary for an infection to occur:**

› Reservoir: Places where infectious agents live (e.g., sinks, surfaces, human skin)
› Susceptible Person with a way for micro-organisms to enter the body
› Transmission: a way micro-organisms are moved to the susceptible person

In healthcare settings, transmission of microbes depends on people, the environment and/or medical devices.

Transmission

The common mechanisms of transmission in healthcare settings, including dental practice are;

Through contaminated hands or gloves for example, **Methacillin-resistant Staphylococcus aureus (MRSA)** contamination on surfaces can be transmitted to patients or other staff via hands. Even whilst wearing latex gloves it is important that these are changed between patients. Many Gram positive bacteria such as MRSA can survive for months on dry surfaces. It has been reported that strains of Staphylococcus aureus can survive on dry surfaces for time periods between 7 days to 7 months (3). Review articles have also noted that bacteria survive on surfaces for longer if there are higher numbers of bacteria and the presence of proteins included as such as serum, sputum or dust (5). Similar MRSA strains were recovered in patients and dental surgery samples after attending a dental clinic (4) indicating transmission from clinic surfaces. Strains of Staphylococcus aureus can be recovered from the surfaces of portable electronic devices such as computers and ipads (Khan et al AJIC 2015). Little work has been undertaken investigating recovery of respiratory tract viruses from dental surfaces, although there has been an investigation of the immune response in dentists to assess their exposure to respiratory virus infections (Davies et al BDJ 1994 176: 262-5) that showed general dental practitioners had significantly raised antibody titres compared to controls for influenza A, B and respiratory syncytial virus.

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Sprays or splashes from dental aerosols, can spread upper respiratory tract viruses, such as influenza. Large contaminated droplets can contaminate surfaces and transmission via hands. Influenza A and B can survive on steel and plastic surfaces for 24–48 hours and cloth, paper and tissues for <8-12 hours (Bean et al. J Infect Dis 2002). Transmission can occur for influenza viruses to steel to hands over a 24 hour period and the virus can survive for approximately 5 minutes on the hands (1). Smaller aerosolised particles can be inhaled or contaminate eyes to cause infection. Attention must also be paid to following manufacturer's instructions on the disinfection of dental unit waterlines.

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Sharp injuries can lead to transmission of infection, for example, Hepatitis B virus can be transmitted when the skin is punctured by a used needle. The risk of Hepatitis B transmission through a contaminated sharps injury from a Hepatitis B positive patient to a non-immune recipient is estimated at 30% (2). A relatively recent example of transmission of Hepatitis B through dental procedures that demonstrates its potentially high infectious nature is that associated with a portable dental clinic in the USA where three patients and two staff were infected with the Hepatitis B virus (Radcliffe et al. J Am Dent Assoc. 2013;144(10):1110-8.). The precise mode of transmission was not detected but multiple breaches in protocols were noted such as close proximity of clean and contaminated instruments, dental handpieces were not sterilized between patients and there was no written records or traceability for the processes used.

What determines the rate of transmission?

The basic reproduction ratio (R0) is a measure of the ability of a pathogen to give rise to more infections or secondary cases. The rate of transmission of a disease is determined by a number of factors in the infectious agent.

Such as, virulence (ability to cause disease) for example the pandemic influenza strains from 1918 is reported to have a higher R0 compared to other flu viruses and host factors, such as immune response (vaccines) – the influenza vaccine is predicted each year to try and match against circulating flu viruses each year. Therefore, the efficacy of the virus can vary from season to season. Nevertheless, it is essential that dental healthcare workers get vaccinated against circulating flu viruses each year to protect themselves and vulnerable patients they maybe treating.

If the R0 is greater than 1 then the infection has potential to spread through a susceptible population. The higher the number the higher the rate of transmission. For measles, R0 is often cited to be 12–18, which means that each person with measles would, on average, infect 12–18 other people in a totally susceptible population. The **R0** for novel **influenza** A (H1N1) has recently been estimated to be between 1.4 and 1.6. It has been estimated the basic reproduction number, R0 to be 1.53 for Hepatitis B (in New Zealand), and shown that the vaccination campaign against Hepatitis B has substantially reduced this below one. R0 estimates for community strains of MRSA (USA 300) the R0 ranged from 1.24 to 1.34.

Protection against transmission

The most practical method to prevent cross-transmission in dental practice is to adhere to standard infection control precautions for all patients as it is difficult to determine which microorganisms patients maybe carrying. It is also vital that all dental staff have received the recommend vaccines and that these are kept up to date and recorded in the practice record management system.

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Transmission of Hepatitis B

Key facts

- Hepatitis B is one of 5 viral hepatitides (named A to E)
- Exclusively transmitted through blood or other bodily fluids
- 257 million people are living with chronic Hepatitis B (WHO estimate in 2015)
- 887 000 deaths annually due to Hepatitis B infections; cirrhosis and hepatocellular carcinoma
- Hepatitis B can be prevented by vaccines that are safe, easily available and depending on the field of employment recommended

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The Hepatitis B virus (HBV) is one of five known viruses described as hepatitis viruses, though, these viruses belong to different virus families. All entities summarized as hepatitis viruses primarily target the liver and cause viral hepatitis (liver infection). The majority of infections are asymptomatic or produce only non-specific symptoms such as anorexia, nausea and vomiting with pain localized in the right upper abdominal quadrant. Jaundice (icterus) known as a hallmark of liver infection tends to develop late, approximately 4 weeks after exposure and anicteric (no signs of jaundice) cases are also very common [1, 2].

HBV is a **blood-borne** infection transmitted by direct contact with either blood or genital secretions, as well as perinatal (mother to child at birth) transmission. Furthermore, HBV can survive on surfaces for at least seven days, thus transmission can also occur via contaminated objects e.g. needle-stick, cut with sharp objects (see also, **transmission of infection**). In the case of medical professionals of any field infections with blood-borne diseases most likely occur through injury. Consequently, Germany and Austria recognised HBV as an occupational hazard for health care personnel [3]. Should a skin breaking injury with a contaminated sharp occur, the probability of acquiring an infection with HBV is 30%. After entering the body and an average incubation period of 75 days, the virus replicates in the liver and sheds virus particles in large amounts into the blood. Consequently, viremia is prolonged, and the blood of infected individuals is highly contagious. The subsequent immune response targets and destroys the host's liver cells. As HBV is 100 times more contagious as HIV and 1µl of blood may contain up to 100 infectious doses of HBV, immunization and post-exposure management are integral parts of workplace safety [1, 2, 4]. Hepatitis C (HCV) eluded identification until 1989 because the virus could not be cultured. The clinical symptoms are comparable to HBV and the same transmissions pathways are applied, though predominantly intravenous e.g. contaminated needles, drug use. Contrary to HBV there is no vaccination available [2].

The main route of transmission in the EU/EEA is sexual contact, while in high prevalence regions such as WHO Western Pacific Region perinatal is a major mode of transmission, due to advances in screening and sterile techniques infections via blood are rare but may occur when sharing razors or needles e.g. acupuncture, injecting drug use [1, 2, 5].

The European Centre of Disease Prevention and Control (ECDC) reports 4.7 million people living with chronic HBV and 3.9 million with chronic HBC within the European Union/European Economic Area (EU/EEA). When taking a closer look at the numbers 24 588 cases of HBV infection were reported for 2018, which corresponds to a crude rate of 6.0 cases per 100 000 population. Out of these cases, 10% were acute, 51% chronic, while the remaining 39% were reported as either unknown or not classifiable. Among the cases with complete information (614 acute/ 2 189 chronic) app. 1.5% could be attributed to occupational injury.

Needle-stick injuries are among frequent occupational injuries in medical professions. These injuries do not only occur during disposal, but also during use. To minimise risk puncture resistant disposal containers and different device safety feature were applied. Nevertheless, safer devices do not eradicate risk staff training. Strict adherence to safety and hygiene protocols are the most important elements in prevention [7].
Due to this prevalent occupational risk HBV vaccination is highly recommended in medical professions, as it provides good protection [6].

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Article Summary

Cross-transmission in the dental office:

Does this make you ill?

Original article by Volgenant & de Soet in
Current Oral Health Reports (2018) 5:221–228.

The article is a review paper of the literature relating to transmission of infections in dental practice. As the authors "aimed to provide the latest insights in the relative risks of transmission of (pathogenic) micro-organisms in the dental office" a number of new scientific publications is presented for which they discuss possible risks of transmission to patients through dental treatment. There is no method section outlining how the literature was searched, but a categorization is provided by the authors in the reference section to indicate important papers.

One major principle is stressed in the beginning: "The prevention of disease becomes more and more important in an era where increased antibiotic resistance results in a rise in untreatable infections." A key element in disease prevention is understanding infection and transmission pathways. Accordingly, three modes of transmission enabling microorganisms to reach potential hosts are exemplified in the text.

Transmission by Direct contact: This can occur via hands, improper sterilised instruments or needle stick accidents. The magnitude of this type of cross-transmission is difficult to estimate as there are no active surveillance programmes in place for post-operative infections in dental practice. Examples given in this section are based on work undertaken on **Methacillin-resistant Staphylococcus aureus (MRSA)** carriage and transmission linked to dental staff or the dental environment. Further difficulties in estimating the risk of transmission in dental practices are highlighted since not all transmissions will result in infection. So, most of these will lead to transient colonization in the case of MRSA rather than infection. Additional studies are discussed, and the authors again showcase challenges in obtaining a good quality evidence base by indicating that the possibility for cross-transmission through dental equipment exists. Although undeniable proof is difficult to obtain, probably due to incomplete reporting and confounding variables.

Transmission by blood contact: A risk of transmission in the dental office exists when pathogens are transported directly from blood (e.g., of the patient) to blood (e.g., of the Dental Health Care Personnel (DHCP). These blood exposure accidents (BEAs) are common in dentistry with frequent work with sharp instruments and needles. In a recent (2016) overview concerning transmission of blood-borne pathogens in the USA, Cleveland et al. found only three reports on cross-infection of HBV and HCV in the dental health care setting. Thus, it is concluded that there is a risk in the dental office, for transmission of blood-borne pathogens but this risk is low. From the perspective of health and safety for DHCP introduction of safety engineered devices or improved injection techniques to prevent BEAs have been recommended and should be adopted wherever possible in dental practice.

Transmission by dental unit water and aerosols: The most reported pathogens from contaminated water are Legionella and Pseudomonas species, but also, opportunistic genera such as Propioniumbacterium, Mycobacterium and Stenotrophomonas species are detected in the dental unit water line (DUWL). In dentistry two cases of legionellosis have been reported recently. However, despite the fact that two people died from a Legionella-pneumonia after a dental treatment, it still is debated whether (contaminated) DUWLs were the source of the Legionella, or that this bacterium had a different origin. Currently, no scientific evidence exists supporting an overall high occupational risk of Legionella infection from DUWL.

In discussion, it is suggested that the research reports described in the review underline the potential for transmission resulting in infection or carriage of micro-organisms. Consequently, maintaining a high standard of infection preventive measures for all patients must take a high priority. But the authors also emphasise their concerns that a number of studies conclude that the knowledge of DHCP about cross-transmission, cross-infection and how to prevent them is low.

A note on relative and absolute risks

A relative risk is a ratio of the probability of an event occurring in the exposed group (in this case patients exposed to dental treatment where there has been a deficiency in infection prevention) versus the probability of the event occurring in the non-exposed group (not receiving dental treatment). Relative risk does not provide any information about the absolute risk of the event occurring but rather the higher or lower likelihood of the event in the exposure versus the non-exposure group.

Thus, to calculate the relative risk, we must know the exposure status of all individuals (either exposed or not exposed). This implies that relative risk is only appropriate for cases where the exposure status and incidence of disease can be accurately determined such as prospective cohort studies – this is very difficult to undertake in dentistry unless one is investigating a specific exposure risk such as, BBV risk in a specific incident investigation.

Relative risks are often reported in newspaper headlines, but without the context of absolute (or baseline) risk, this information is meaningless. Absolute risk numbers are needed to understand the implications of relative risks and how specific factors or behaviours affect the likelihood of developing a disease or health condition.

Absolute risk is the actual risk of some event happening given the current exposure. Absolute risks are needed to understand relative risk. This is very difficult to calculate for routine dental treatment as there is little or no data on adverse events in treated and/or control groups.

For more details on risk see
https://www.harding-center.mpg.de/en/persons/gerd-gigerenzer

Or
D Spiegelhalter https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2937730

Cited article:
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https://doi.org/10.1007/s40496-018-0201-3

Bacterial contamination of dental instruments:

Risk of infectious-disease transmission for patients and practice staff

Microbiology is a multi-disciplined science that covers many different forms of life. This includes bacteria, fungi, parasites and viruses (some argue that prions are not classed as a life form, since they do not possess DNA or RNA). These microbes can have a beneficial as well as more harmful interactions with humans. Within the oral cavity all these forms of micro-organisms can be found and many can present a hazard to patients or staff in the absence of high quality infection prevention protocols.

Pseudomonas spp., Legionella spp. and multi-resistant bacteria are particularly relevant (4). Cross-infection of the **Hepatitis B** virus poses a particular challenge to dental medicine.

Table 1: Pathogenic germs and their incubation times
(adapted from the publication by Stephanie J. Dancer (5)):

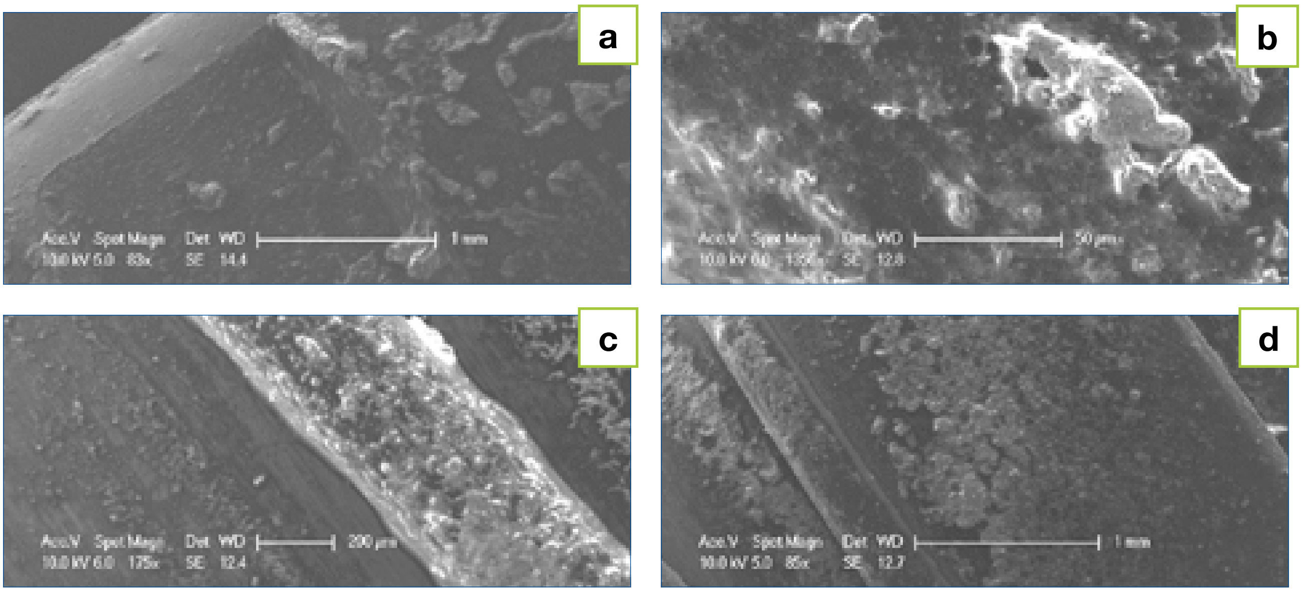
Pathogenic germ	Possible disease incubation period
Herpes simplex virus	Up to two weeks
Varicella-zoster virus	2–3 weeks
Hepatitis B/C/D virus	Up to six months
HIV/AIDS	Months to years
Mycobacterium tuberculosis	Up to six months
Pseudomonas spp	3–10 days
Legionella spp.	2–19 days
Staphylococcus aureus	4–10 days

A number of studies (1, 2, 3) have proved that oral bacteria and body fluids such as blood and saliva contaminate both the outside and inside of dental handpieces for example, in gear units and spray and air channels.

The study by Gordon Smith and Andrew Smith investigating the contamination of the internal components of transmission instruments is one example (3). It recorded the following results:

Approximately 200 CFU* were detected per turbine handpiece (n = 40), 400 CFU per spray channel (n = 40) and 1000 CFU per instrument of surgical equipment (n = 20). Among the bacteria detected were Streptococci, Pseudomonas spp. and Staphylococcus aureus. These bacteria can cause infections under the right conditions, these findings highlight the potential for cross-infection and the importance of effective decontamination (cleaning and sterilization). This can be particularly challenging within the lumens and gearing of the handpiece.

See below for several photos, reproduced with the kind permission of Dr Gordon Smith and Dr Andrew Smith, Institute of Infection, Immunity & Inflammation, College of Medical, Veterinary and Life Sciences, Glasgow Dental Hospital and School, University of Glasgow, Glasgow, Scotland



Images: Examples of contaminants that were found on decontaminated surgical devices. All the figures described previously were from before decontamination. The organic contaminant in picture (a) is shown at 83x magnification. The contaminant encased in lubricant in picture (b) is shown at 1356x magnification. The contaminant in picture (c) is shown at 175 x magnification and the sulphur-based contaminant in picture (d) is shown at 85x magnification.

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* CFU: Colony-forming unit, is a quantitative measure of the number of colonies found on an agar plate.

How many CFU does it take to cause disease?

Having established the number of CFUs in the above-mentioned studies, a legitimate question might naturally now arise regarding the infectiousness of each quantity of CFUs found. A published review on the topic of infections acquired in hospital by Stephanie J. Dancer.

Stephanie J. Dancer puts the survival of a dangerous Methacillin-resistant Staphylococcus aureus between at least seven days and up to seven months. Only a few CFU are required to cause an infection; the review by Dancer puts the number at four CFU. Further detailed information can be found in the published review by Stephanie J. Dancer (5).

Standard infection control precautions

Since it is difficult to identify patients that may be asymptomatic for a number of infectious diseases, the safest and most logical approach to dental treatment that limits the risk of cross-infection is to treat all patients to the same high standard, this is referred to as **Standard Infection Control Precautions (SICPs).**

This approach is internationally recognised and adopted in all fields of healthcare. Essentially it means that regardless of patient infectivity, the standard protocols for infection prevention in the dental practice should be of the highest standard for all patients. This also includes the reprocessing of dental instruments. Implementation of SICP's in dental practice will require appropriate staff training with competency assessments and periodic updates.

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