Current issues in infection control practices in dental hygiene - Part II

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ABSTRACT

This article is a continuation of Infection control practice guidelines–Part 1 (vol.42.2). Part II discusses four current issues including compliance with infection control practices, HIV, HBV and HCV, dental unit water lines, and aerosols. Part II provides recommendations for dental hygienists, educational institutions, several dental hygiene organizations, the National Dental Hygiene Certification Board, the Commission on Dental Accreditation Canada, and researchers.

RÉSUMÉ

Cet article fait suite à la première partie du Guide de prévention des infections dans la pratique de l'hygiène dentaire (vol.42.2). Le deuxième volet qui traite des problèmes courants dans la prévention des infections, se penche sur quatre problèmes actuels, notamment: l'observance des pratiques de prévention, le VIH, le VHB et le VHC, les conduites d'eau des unités dentaires et les aérosols. Le deuxième volet formule des recommandations destinées aux hygiénistes dentaires, aux établissements de formation, à plusieurs organismes d'hygiène dentaire, au Bureau national de la certification en hygiène dentaire, à la Commission d'agrément dentaire du Canada et aux chercheurs.

COMPLIANCE WITH INFECTION CONTROL PRACTICES

Infection control is an aspect of the accreditation requirements for dental hygiene programs in Canada,[15] and the National Dental Hygiene Certification Board[16] has competencies on this topic. Although these documents were not reviewed in detail for the degree of inclusion of infection control issues, their inclusion suggests that dental hygienists are educated to some degree in infection control issues. Although this provides some reassurance that an entry level dental hygienist has some knowledge about infection control, several surveys of oral health professionals indicate that there may be gaps in knowledge and in implementation of infection control. A study in 1999 of 6,444 dentists in Canada indicated several areas of weakness in complying with guidelines for infection control.[17] The study found dentists used gloves, masks, and protective eyewear. However, they were only partially compliant with a number of other guidelines such as hand washing before and after gloving. In addition, compliance with testing for an immune response after HBV immunization ranged from 49 per cent of dentists in Manitoba to 78 per cent in the Northwest Territories. Furthermore, the range of dentists who were flushing dental unit waterlines (DUWL) after each client ranged from 20%-68%. To address these practice gaps, the authors of the study called for mandatory continuing education on infection control.

In 2001, a systematic review of seventy-one poor quality studies[18] showed that oral health care professionals' adherence to guidelines for infection control worldwide had improved over time in such areas of infection control as glove wearing and sterilization of handpieces; however other aspects as vaccination follow up, post-exposure follow up and impression disinfection are measures that remained problematic. The authors made several suggestions for improving knowledge and consistent use of infection control practices, including formal training, certification and an independent body, used by many countries for practice inspections. A study in 2005 in the USA of attitudes and practices of 856 dental hygienists to infection control indicates that there has been an improvement in compliance with guidelines for infection control compared to an earlier study.[19] However the authors suggest that dental hygienists still have misconceptions regarding infectious diseases and disease transmission.

HUMAN IMMUNODEFICIENCY VIRUS, HEPATITIS B VIRUS AND HEPATITIS C VIRUS

There is a small risk of transmission of Human immunodeficiency virus (HIV), hepatitis B virus (HBV), and hepatitis C virus (HCV) from client to dental hygienists, from dental hygienists to client, or from client to client.[1] The risk of transmission of HBV, HCV and HIV, as a result of a needlestick or percutaneous injury are approximately 30 per cent for HBV, 1.8 per cent for HCV, and 0.3 per cent HIV.[20,21] The risk for HIV transmission following a mucous membrane exposure is approximately 0.09 per cent. Although HIV transmission following non intact skin exposure, and fluids and tissue exposure other than blood, have not been quantified, the former is estimated to be less than the risk for mucous membrane exposure; and the later is estimated to be less than for blood exposure.[22] Although oral health professionals are at a low risk for occupationally acquired HIV, serological tests indicate that oral health professionals have a ten times greater risk of becoming chronic Hepatitis B carriers than the average citizen.[19]

There are various national and international reports of how this risk affects dental hygienists' lives.

- Health Canada has reported three known cases of health care workers who are occupationally infected with HIV.[23]
- As of June 1999, there were 310 reports of occupationally acquired HIV among health care workers worldwide. Of these, 102 cases were confirmed and of the remainder of the possible cases, 9 were dental workers.[24]

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- As of 2001 in the USA, there were no dental health care professionals among fifty-seven health care professionals with documented HIV seroconversion following a specific exposure to a known HIV infected source.[21]
- Research from 2001 in the UK estimates that there are twelve needlestick injuries per million hours worked in a dental setting.[25]
- Researchers from a study in Washington State collected data on workers' compensation claims and found that "out of hospital" percutaneous injuries are a substantial risk to their oral health care workers. During a 7-year period (1995-2001) there were 924 percutaneous injuries reported. Out of these injuries, 894 (97 per cent) were among dental health care workers in non hospital settings, including 66 dentists (7 per cent), 61 dental hygienists (18 per cent) and 667 dental assistants (75 per cent). Causes of these injuries in descending order included syringes, suture needles, and dental instruments. Of the 894 dental health care workers with percutaneous injuries, there was evidence of HBV in six persons, HCV in thirty persons, HIV in three persons and both HBV and HVC in two persons.[26]

Some researchers identify underreporting of occupational exposure to bloodborne pathogens as a significant problem in the health care workplace.[27] In 2006, McCarthy et al.[28] reported only three cases of occupationally acquired HIV among health professionals. However, there is a discrepancy between this number and the numbers of self reported exposure by health professionals and the number of confirmed acquired cases of HIV from Workers' Compensation Boards.[28]

In one study, Canadian dentists report an average of three percutaneous injuries and 1.5 mucous-membrane exposures per year. "In a one-year period, 0.5% of dentists in Canada reported exposure to HIV and an additional 14% were uncertain if the source patient was HIV seropositive; similarly, 0.8% reported exposure to HBV (15% uncertain) and 1.9% reported exposure to the blood of a high-risk patient (17% uncertain)."[21] A survey conducted in 2000 of 22,000 Canadian dentists, dental hygienists, surgeons and nurses indicates that approximately 1 in 200 dental hygienists reported being exposed to HIV-infected blood in the previous year.[28] In addition, the Association of Workers' Compensation Boards of Canada indicates that twenty nurses received compensation for time lost as a result of occupationally acquired HIV infection in 1999 alone.[29] These reports indicate that governmental reports may underestimate the number of health professionals who are exposed to HIV. Given the possibility of underreporting, combined with the reports of a lack of compliance with guidelines for infection control, there is a need to examine more seriously the issue of infection control in the dental hygiene practice setting.

Although there is the potential for transmission of HIV, HBV, and HCV from dental hygienist to client, to date there are no reports of this occurring. The following outlines the history of transmission from health practitioner to client and from client to client.

- In 1987, there was a case of HBV transmission from a US[30] dentist to a client, and in 1990, there was an incident of possible transmission of HIV from a dentist in Florida to six clients.[24]
- In 1997, there was also a case of client to client HIV transmission via contaminated dental instruments.[24]
- In 1998, a client in France developed HIV following orthopedic surgery, and from 1992 to 1996, 75 clients developed hepatitis B following the placement of subdermal needle electrodes, by an EEG technician who was a carrier of hepatitis B.[31]
- In 2001, there was a report of the only known case of HBV transmission between dental clients in the United States, during routine oral surgery.[30]

These incidents underscore the need for meticulous infection control measures. A dental hygienist's failure to comply with guidelines for infection control may result in a client developing a serious illness and subsequently taking legal action against the dental hygienist.

Public attitudes and opinions regarding oral health professionals infected with HIV and HBV have not changed over the last ten years. A survey of approximately 2,300 individuals conducted in 2005 indicates 89 per cent wanted to know if their oral health professional was infected with HIV, HBV or HCV.[32] In 1991, the Centers for Disease Control and Prevention (CDC) in the USA published guidelines that addressed this public concern.[33] Although the CDC did not recommend mandatory testing of health care workers for HIV antibodies, Hepatitis B surface antigens (HBsAg), and Hepatitis B e Antigens (HBeAg), the CDC recommended that health care workers who perform exposure prone procedures should know their HIV antibody status. And, health care workers who are infected with HIV or HBV should not perform exposure prone procedures unless they have sought counsel from an expert review panel, and been advised under what circumstances, if any, they may continue to perform these procedures. Exposure prone procedures include certain oral procedures and the CDC recommends that dental organizations and institutions, where the procedures are performed, should define these procedures.

In keeping with the CDC's call for an expert review panel, the Interpretation Guidelines section of the Registrants Handbook[5] of the College of Dental Hygienists of British Columbia (CDHBC) outlines the requirements when a dental hygienist is infected with bloodborne pathogens (Appendix B). To balance public protection with the rights of the dental hygienist to practise, the CDHBC requires that dental hygienists, who are infected with bloodborne pathogens, are obliged to contact the chairperson of the Bloodborne Pathogens Committee for guidance with their practice. The CDHBC maintains confidentiality as dental hygienists make contact with the Chairperson of the committee anonymously. This ensures the fair treatment of dental hygienists, and that they act professionally and safely.

In Canada, there is some indication of regional differences in access to dental hygiene services for individuals with HIV/AIDS. A Canadian study in 2006 found three per cent of dental hygienists in British Columbia, and twelve per cent of dental hygienists in Ontario would refuse to treat people with AIDS/HIV.[34] Refusal to treat was also

associated with a two-year diploma program, as opposed to a baccalaureate program. This study also shows that employer's attitudes about treating clients with AIDS/HIV affect dental hygienists attitudes about treating clients, with 23 per cent of dental hygienists who indicated they would refuse to treat a client with AIDS/HIV also indicated that a dentist who is reluctant to treat HIV clients employed them. Dental hygienists' willingness to treat clients with HIV/AIDS may also be related to knowledge of the disease process, and how to treat clients with communicable disease.[35] This is confirmed by a study in the USA in 2003 indicating that only 58.4 per cent of dental hygiene students reported that their studies prepared them to treat patients with communicable disease.[36]

In 2005, the CDC published new guidelines for the management of occupational exposure to HIV.[22] This updates the information from the CDC *Guidelines for Infection Control in Dental Health-Care Settings*-2003. The new guidelines emphasize adherence to HIV post exposure prophylaxis (PEP), expert consultation in management of exposures, follow up of exposed workers to improve adherence to PEP, and monitoring for adverse events, including seroconversion. Emphasis is on the need for urgency in assessment and treatment, which should preferably be given within hours of the exposure. A survey shows that the annual median time to initiation of PEP was two hours, indicating that clinicians are being assessed and treated in a timely manner; however, only 289 of 1,350 health care professionals had a follow up serological test at 4-6 months, (the guidelines recommend testing up to six months) indicating that these individuals did not have up-to-date information regarding their HIV status. The six-month follow up is critical as the guideline indicates that the PEP is not always effective, since there are a total of six documented cases of HIV seroconversion, following a combination HIV PEP.

In September 2006, the CDC issued new recommendations for routine, voluntary HIV screening in health care settings for all persons 13-64 years of age, regardless of risk profile, and annual repeat for individuals with a known risk.[37] The rationale for this recommendation include new research that knowing ones serostatus substantially reduces high risk behaviours. Data indicates screening is cost effective, and evidence that late testing and diagnosis is common. Although this is a recent CDC recommendation, researchers have already started to survey educators to determine attitudes towards screening. A survey of 100 dental educators at forty-six dental schools in the U.S. indicates that one third of respondents would perform HIV testing (using a rapid oral fluid based test), counselling, and referral.[38] Educators thought that additional training was needed in promoting health behaviours, particularly HIV prevention. Most educators felt that graduates lacked the skills and willingness to conduct HIV testing.

DENTAL UNIT WATER LINE (DUWL)

Dental unit waterlines are an integral part of dental hygiene equipment, supplying water for high-speed handpieces, ultrasonic scalers and air/water syringes. It is common for DUWLs to be contaminated by many species of microorganisms, including twenty eight species of bacteria (*Staphylococcus aureus, Mycobacterium avium, Legionella pneumophilia* and *Legionella spp*), five species of fungi, and four species of protozoa.[39] The contamination of the line occurs when oral fluids are passively retracted into the waterline, when the equipment is turned off. Water stagnation, high surface to volume area, and intermittent patterns of water use combined with poor waterline management culminate in high numbers of microorganisms.[40] Some of these microorganisms form biofilm in the lines, which are harder to remove than the free floating microorganisms, since they have a protective extracellular matrix. The biofilm protects the bacteria not only from being washed away by the water flow, but also from many types of antimicrobial water treatment.

Microorganisms in the DUWL could negatively affect the health of dental hygienists due to exposure to aerosols, which may be inhaled, and splattered on the skin. Microorganisms could also result in nosocomial infections in clients, due to contaminated water from the DUWL being flushed into their oral cavity during treatment, or inhalation of the aerosols. There are reports associating waterborne infections with dental water systems with scientific evidence of the potential for transmission of infections and disease from DUWL. However research has not demonstrated a high risk of adverse health among dental hygienists or their clients.[7] Although there may not be a high risk, the section of the paper entitled, "What is the connection between contaminated DUWLs and respiratory disease in dental hygienists?" provides several lines of evidence suggesting a potential connection between DUWL contamination and respiratory disease transmission. The lack of evidence of a widespread public health problem may be reassuring, however falsely, since the lack of evidence may also reflect the difficulty of establishing epidemiological links between dental care and infections with extended incubation times.[39]

Given the best available evidence which suggests a potential risk associated with contaminated DUWL, the CDC issued a statement regarding appropriate precautions, "exposing patients or dental health care personnel to water of uncertain microbiological quality, despite the lack of documented adverse health effects, is inconsistent with generally accepted infection control principles."[7] There are several ways to avoid or minimize the contamination of DUWLs, including running water to flush out microorganisms, rinsing the DUWL with disinfectants, the use of self contained water systems, placement of bacteriological filters in the waterlines to remove microorganisms, and retraction devices.

What is the role of flushing DUWL?

All of the infection control guideline documents reviewed in Table 1 (published in Part I of this document in the previous issue, 42.2) recommend flushing the line in between clients, to physically flush a client's debris that may have entered the waterline from the previous client, in order to maintain water that is ≤500 mean colony-forming units per millimetre (CFU/mL). Although the CDC's recommendation for the maximum level of contamination of the waterline is <500 mean CFU/mL, which is mirrored by the US Environmental Protection Agency in their limits for

heterotrophic bacteria in drinking water,[41] the European Union's infection control standards call for a higher standard of 100 CFU/mL.[42] Canadian guidelines for drinking water are:

- 0 per mL for *E.coli*,
- 0 per mL for total coliforms, and
- no numerical guidelines are given for heterotrophic plate count.[43]

A review of four studies from 2001-03 concludes that flushing waterlines for a few minutes may reduce the concentration of planktonic bacteria; however, flushing is not able to remove the biofilm.[44] A study in 2006 examined flushing of DUWLs specifically for the removal of protozoa, and *Legionella spp*, a pathogenic agent that has been shown to be transmitted in aerosols.[45] Studying this pathogen is of particular interest, since oral health professionals were found to have substantially higher concentrations of *Legionella* antibodies compared to the general population.[46] The study found that flushing was relatively ineffective in removing *Legionella spp* and protozoa from the DUWL. It appears that flushing, like microfiltration, removes microbes that have budded off from the mature biofilm, but it is unable to remove the microorganisms present in the biofilm that have adhered to the walls of the waterlines. These studies confirm the importance of the CDC's guidelines (2003) recommending that flushing alone is not a reliable procedure for improving water quality.[7] Additional methods to flushing, for example chemical agents, are necessary.

Table 2: Reduction in total viable counts (TVC) of bacteria in the water in DUWL

Disinfectant	Chate, 2006 (46) (W) %	O'Donnell et al. 2006 (47) (W)	Schel et al. 2006 (48) (C) & (D)	Meiller et al. 2004 (49) (D)	McDowell et al. 2004 (50) (D)	Spratt et al. 2004 (51) (I)	Porteous et al. 2004 (39) (W)	Walker et al. 2003 (52) (W) %	Wirthlin et al. 2003 (53) (D)	Montebugnoli et al. 2003 (54) (P)
Alpron (chlorite based)	100		87% of samples <200 CFU/mL (C) **							
Sterilox* Continuous application	100							100		
Sodium hypochlorite	100									
Bio 2000 (ethanol and chlorhexidine)	100							53		
Combizyme								70		
Ozone								65		
Chlorhexidine (CHX)							Reduced to <200 CFU/mL	100	Reduced to <200 CFU/mL	
Tegador								100		
Gigasept Rapid (aldehyde based)								100		
Grotanol (hydroxide based)								100		
Grotanol Flussig (phenol based)								100		
Beta-dine (povidone-iodine based)								100		
Sporkleanz*								100		
Sterilex Ultra*								100		
Dialox								100		

Continued…

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Disinfectant	Chate, 2006 (46) (W) %	O'Donnell et al. 2006 (47) (W)	Schel et al. 2006 (48) (C) & (D)	Meiller et al. 2004 (49) (D)	McDowell et al. 2004 (50) (D)	Spratt et al. 2004 (51) (I)	Porteous et al. 2004 (39) (W)	Walker et al. 2003 (52) (W) %	Wirthlin et al. 2003 (53) (D)	Montebugnoli et al. 2003 (54) (P)
Sanosil*								100		
Oxigenal*			91% of samples <200 CFU/mL (C)					100		
Grotanat Bohrerbad*								100		
Chlorine Dioxide									100%	
Alkaline perioxide									Unacceptable reduction	
Planosil (hydrogen peroxide and silver)		Intitial reading: 15,400 CFU/mL Final reading: 26 CFU/mL								
Planosil Forte (hydrogen perioxide and silver)		Intitial reading: 15,400 CFU/mL End reading: 26 CFU/mL								
Peracetic Acid										Initial reading: >200 CFU/mL Final reading: not detectable
Dentosept			91% of samples <200 CFU/mL ** (C)							
Ster4Spray			60% of samples <200 CFU/mL ** (D)							
BioBlue			Inconsistent effect (D)							
A-dec ICX (sodium per-carbonate, silver nitrate and cationic surfactants)				100%	Below detectable limits (3CFU/ mL)					
TAED and sodium perborate						Below detectable limits				

Table legends: (W) Weekly application, (D) Daily application, (P) Prior to each client, (C) Continuous, (I) In-vitro experiment
** Occasional high values above 200 CFU/mL were found, * Hydroxide-containing products, TAED Tetraacetylethylenediamine

Can the line type affect the level of microorganisms?

There is some preliminary evidence that the line material and the size of the line may help to reduce biofilm formation and reduce bacterial outflow.

- A study in 1988 found that polytetrafluorethylene (PTFE) tubes had negligible microbial growth compared to polyethelene (PE tubes).[44]
- In addition, a study conducted in 2005 found that tubes made from fluoridated resins were effective in inhibiting biofilm formation and in reducing bacterial outflow.[47]
- A study conducted in 2007 compared two waterline materials and two sizes of lines and found that lines made from PTFE compared to lines made from PE and the larger sized lines, 4 mm compared to 1.6 mm, had less bacteria. However, the level of microorganisms was still not within acceptable limits.[44] This study was important in showing that the PTFE line did not contain any *pseudomonas aeruginosa* and the authors suggest that the PTFE line may have inhibited the growth of this type of bacteria.

How does the type of line cleaner impact on the level of microorganisms?

The CDC's guidelines on infection control state: "Dental unit water that remains untreated or unfiltered is unlikely to meet drinking water standards. Commercial devices and procedures designed to improve the quality of water used in dental treatment are available; methods demonstrated to be effective include self-contained water systems combined with chemical treatment, in-line micro filters, and combinations of these treatments. Removal or inactivation of dental waterline biofilm requires use of chemical germicides."[7]

Dental hygienists use disinfectants or line cleaners to flush dental unit water lines to minimize odour, remove solid waste particles, remove biofilm, and maintain low microbial counts in the DUWL. Several studies have been conducted recently examining the impact of line cleaners on the level of microorganisms. Information from ten controlled studies is arranged in evidence tables 2 and 3. Table 2 shows reduction in total viable counts (TVC) of bacteria in the water from the DUWL and table 3 shows reduction of biofilm coverage within the DUWL.

Table 3: Percentage reduction of biofilm coverage within the DUWL

Disinfectant	Chate, 2006 (46) (W) %	O'Donnell et al. 2006 (47) (W)	Schel et al. 2006 (48) (C) & (D)	Meiller et al. 2004 (49) (D)	McDowell et al. 2004 (50) (D)	Spratt et al. 2004 (51) (I)	Porteous et al. 2004 (39) (W)	Walker et al. 2003 (52) (W) %	Wirthlin et al. 2003 (53) (D)	Montebugnoli et al. 2003 (54) (P) %
Alpron	100									
Sterilox	99							95		
Sodium hypochlorite	94									
Bio 2000 (ethanol and chlorhexidine	53									
Combizyme								70		
Ozone								65		
Chlorhexidine (CDX)								31		
Tegador								33		
Gigasept Rapid (aldehyde based)								34		
Grotanol (hydroxide based)								64.9		
Grotanol Flussig (phenol based)										
Beta-dine (povidone-iodine based)										
Beta-dine (povidone-iodine based)										
Sporkleanz*								95		

Continued…

Table 3: Percentage reduction of biofilm coverage within the DUWL

Disinfectant	Chate, 2006 (46) (W) %	O'Donnell et al. 2006 (47) (W)	Schel et al. 2006 (48) (C) & (D)	Meiller et al. 2004 (49) (D)	McDowell et al. 2004 (50) (D)	Spratt et al. 2004 (51) (I)	Porteous et al. 2004 (39) (W)	Walker et al. 2003 (52) (W) %	Wirthlin et al. 2003 (53) (D)	Montebugnoli et al. 2003 (54) (P) %
Sterilex Ultra*								95		
Dialox								95		
Sanosil*								95		
Oxigenal*								95		
Grotanat Bohrerbad*								95		
Chlorine Dioxide										
Alkaline perioxide										
Planosil (hydrogen peroxide & silver										
Planosil Forte (hydrogen perioxide and silver)										
Peracetic Acid										100
Dentosept										
Ster4Spray										
BioBlue										
A-dec ICX (sodium percarbonate, silver nitrate and cationic surfactants)				100 (new lines only)	No evidence of biofilm formation					
TAED						Below detectable limits				

Table legends: (W) Weekly application, (D) Daily application, (P) Prior to each client, (C) Continuous, (I) In-vitro experiment, TAED Tetraacetylethylenediamine

What is the best way to monitor the DUWL?

DUWL monitoring is required in order to determine the level of microorganism contamination in the line. The CDC recommends consulting with the manufacturer of the DUWL to determine the best method for maintaining acceptable water quality and frequency of monitoring. The CDC also suggests monitoring with an in-office self-contained test kit or commercial water-testing laboratories to determine TVC.[7]

Research contributing to this topic comes from three studies examining different types of monitoring systems and one study examining transportation methods and time delay in laboratory testing. In 2004, a study investigated an easy to use chairside assay as an alternative to TVC.[42] TVC is the normal method of measuring bacterial contamination in a lab; however, it is time consuming, labour intensive and has a time delay element. The study determined that measures of total adenosine triphosphate (ATP) concentrations in DUWLs samples were too insensitive and did not correlate with TVC data, and were therefore not reliable methods of testing DUWLs. The researchers found an endotoxin assay method was relatively expensive, and required specialist expertise and equipment. Therefore, it may not be practical for use in a dental hygiene practice. In 2005, another study found that the measurement of the total cultivable mesophilic flora (TCF), a parameter commonly used to monitor water quality in DUWL is not an effective predictor for the presence of oral streptococci (OS).[48] Although the authors suggest caution in the interpretation of the study owing to low power of statistical analysis, they suggest measuring the OS in addition to TCF.

In 2006, a study examined the validity of two in-office

water test kits — the HPC Dental Sampler and the Clearline Water Test Kit compared to the gold standard dehydrated culture medium R2A agar for monitoring DUWLs.[41] The researchers, Bartolini and colleagues, processed 351 split samples and found that the in-office kits generally underestimated the bacteria levels and their accuracy ranged from 25%-69%, compared with the R2A agar. Therefore, use of these kits could lead to a lack of compliance with the guidelines for infection control. This study confirms some earlier work by Smith and colleagues,[49] who also found that the HPC Dental Sampler failed to grow some bacteria. Karpay and colleagues studied the HPC Dental Sampler and found that it agreed with the R2A agar 92 per cent of the time.[50] Bartolini and colleagues point out that the difference may partly be accounted for by the fact that Karpay used a more efficient DUWL cleaner that may have increased the accuracy of the tests. These results suggest a need to conduct more research on this topic in order to determine an effective method for testing DUWLs that yields high quality data.

In 2005, a study examined different transportation methods and measured the effects of delayed culturing on DUWL specimens.[51] The specimens were collected from high-speed handpiece service lines. The handpieces were removed before the water was collected. Delaying specimen culturing even one day at ambient temperatures, and exposing specimens to a variety of environmental conditions resulted in unreliable bacterial counts. Analyzing the specimens immediately or sending them by express mail, with a cooling element that remains intact upon arrival at the laboratory produced reliable results.

What is the connection between contaminated DUWLs and respiratory disease in dental hygienists?

DUWLs that are contaminated with microorganisms can result in the contamination of aerosols. The microorganisms in aerosols contain endotoxins, such as lipopolyssacharides, which may have a negative impact on the health of dental hygienists and their clients. The previously mentioned high count of *Legionella* antibodies among oral health professionals may be subclinical infections which are most likely due to chronic exposure to *Legionella* contaminated aerosols from DUWL,[39] although respiratory infection transfer may result from three modes of transmission, including large droplets, or direct contact with secretions which occur when the health professional has direct contact with the client, and also through aerosols. A review of aerosol transmission indicates that these three modes are not mutually exclusive and that aerosol transmission of influenza can be an important mode of transmission.[52] The evidence of several modes of transmission and a lack of compliance with guidelines for infection control underscore the need to improve infection control within dental hygiene practices.

Epidemiological information and research studies show mixed evidence on the connection between contaminated DUWLs and respiratory disease; however, the broader medical research which follows, shows a connection between airborne bacteria and poor health. Epidemiological information from a Finnish occupational health registry indicates that respiratory illness in dental health professionals accounts for 6.4 per cent of occupational disorders.[40] A study in 2005, in London, England, and Northern Ireland, found that the onset of asthma in dentists may be associated with occupational exposure to contaminated DUWL.[40] This study found that in a population of 266 randomly selected dentists 14 per cent reported suffering from asthma, and that higher aerobic counts (>200 CFU/mL) in the DUWL were associated with the onset of asthma. A study in the USA in 2005 contradicts this study and reports that asthma rate in the dental/dental hygiene student/graduate population is lower than the Northern Ireland/London, England study. Prevalence rates of 1.7%-5.5% were reported for 817 American dental students and post-graduate residents, and 26 dental hygiene students.[53] The authors of this study conclude that there is no statistically significant association between dental school attendance and respiratory disease.

Other evidence on this topic comes from studies that do not specifically examine oral health professionals. Three other studies in the medical literature conducted between 1995 and 2000 also show a significant association between prevalence and severity of asthma and raised concentration of airborne bacteria in the indoor environment.[40] Further support for this association comes from a review of the epidemiological studies on occupational airway disease in agricultural and textile workers, demonstrating that the concentration of bacteria in the working environment is the major predictor of this disease.[54]

AEROSOLS AND SPATTER

Aerosols are not droplets, they are invisible particles, less than 10 microns in diameter, which float on air currents.[55] Aerosols are produced in a dental hygiene practice from rotary instruments, air abrasion, air-water syringes, ultrasonic scalers, and during air polishing. The material in the aerosol, which is contaminated with microorganisms, originates from the treatment site and the DUWL. The use of personal barrier protection, sterilization of instruments and treatment of DUWLs will eliminate much of the risk of transmission from aerosols.[56] Although there are no known cases of transmission of a bloodborne pathogen by aerosols in a clinical setting[55], the small particles of an aerosol may contaminate environmental surfaces, or enter the lungs and create the potential for transmitting infections.[56]

Spatter droplets can be defined as airborne particles larger than 50 µm in diameter.[56] These particles are too large to become suspended in the air and are airborne only briefly. The CDC recommends barrier precautions such as face shields, masks, gowns to prevent contact with airborne particles. Some of the diseases known to be spread by droplets or aerosols include pneumonic plague, tuberculosis, influenza, Legionnaires' disease, and SARS.[56]

The CDC's infection control guidelines recommend that dental hygienists wear masks during procedures and client care, when such activities are likely to generate splashes or sprays of blood or body fluids.[7] However some preliminary research shows that protection may be needed not only during the procedure, but also for a period following the procedure, to reduce the risk of coming into contact with aerosols that remain in the room air for a period. One study on this topic shows that aerosols may be present in the op-

eratory for up to 30 minutes after a procedure.[57] While this study is important in improving our understanding of flow of aerosols in the operatory, it was not designed to show a link between aerosols and increased infection related to aerosols.

A review of the literature in 2004 on reducing airborne contamination identifies several methods for reducing airborne contamination.[57] Two studies indicate that a reduction in aerosol contamination can be obtained with the use of a 0.1 per cent chlorhexidine or essential oil-containing mouthwash for one minute before a dental procedure. However, this will only act on free floating oral bacteria, not those adhering to mucous membranes or in biofilm. The use of a rubber dam will also reduce the contamination arising from saliva or blood. However, a rubber dam is not suitable for dental hygiene procedures such as root planning, and routine prophylaxis. The use of a high efficiency particulate air filter, or HEPA filter and the use of ultraviolet, or UV chambers in the ventilation system can reduce airborne contamination. However, this equipment may be rather expensive and it may take an extended period for the air in the treatment room to cycle through the ventilation system. Five studies were identified which indicate that the use of a high volume evacuator (HVE) may reduce the contamination arising from the operative site by more than 90 per cent. A saliva ejector does not classify as a HVE, since it does not remove a sufficient volume of air. The CDC supports the use of a rubber dam where possible, and the routine use of HVEs for reducing contaminated spatter.[58]

Several studies show that the area contaminated by aerosols is much larger than previously thought:

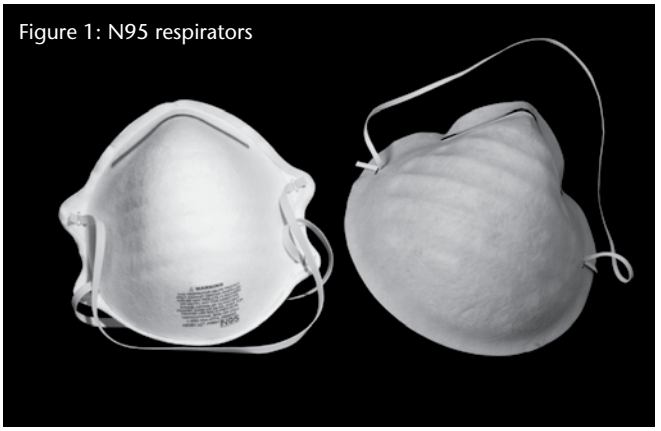
- A study in 2005 found particulate concentrations of bacteria at a reach of nearly eight feet.[59]
- This large area of bacterial aerosol contamination is also confirmed by a study in 2006, which found that the area contaminated by aerosols was 1–1.5 metres from the client's mouth and bacterial counts were generally higher in the more remote sampling points.[60] Based on these findings, the authors suggest that the only items on the dental operatory counters should be the items for ongoing treatment, and other items should be stored in closed cupboards.

The risk from aerosols has also come to the forefront in recent public health pandemic planning.

- In May 2007, the CDC issued a recommendation that people should wear an N95 respirator (in the context of an overall respiratory protection program) if they expect to be in close contact with people who are known or thought to be sick with pandemic flu.[61]
- In addition, the PHAC indicates that when performing or assisting with aerosol generating procedures, on a patient with a known or suspected influenza caused by the pandemic influenza strain, all health care workers in the room should wear a sub-micron particulate respirator, such as the N95.[62]

An N95 respirator as shown in figure 1 provides more protection than a surgical mask in providing a barrier against viruses. The N95 respirator screens out 95 per cent of the particles that are 0.3 microns and larger. Like surgical masks, the respirators are for single use only.

Figure 1: N95 respirators



DISCUSSION AND CONCLUSIONS

The CDC's *Guidelines for Infection Control in Dental Health-Care Settings* is a comprehensive document that is supported by research and expert opinion. Infection control is a complex topic and the CDC's guidelines are lengthy and cannot be distilled into a simple one-page synopsis. These guidelines do not describe all dental hygiene settings or all situations that occur in dental hygiene practice. Therefore, dental hygienists should incorporate relevant components of the CDC's guidelines into their practice and make decisions about specific procedures, based on their knowledge of the principles of infection control.

There are instances when more stringent guidelines must be followed when, for example, institutional or office policies supersede the CDC's guidelines. In addition, dental hygienists should incorporate into practice the more stringent guidelines, identified in Appendix A (published in Part I of this document in the previous issue, 42.2). If the provincial or territorial statutory infection control requirements set by the government or regulatory bodies conflict with the CDC's guidelines, then dental hygienists are required to follow the statutory requirements. Self audits can assist in determining how practices adhere to or deviate from the CDC's guidelines.

There may be instances when dental hygienists may work in practice settings with less rigorous guidelines for infection control or policies on treating clients with AIDS/HIV that conflict with human rights legislation. In these instances, it is up to the dental hygienist to assess the office policy and determine if it meets the guidelines set out by their regulatory body and the federal/provincial legislation. With an increasing number of dental hygienists establishing private dental hygiene practices, and an increase in self regulation, it will become increasingly easier to promote infection control standards with safety and fairness for dental hygienists and the public.

The discriminatory practice of refusing to treat clients with AIDS/HIV is associated with a lower level of education, employers upholding the same practice, as well as geographical location (Ontario's dental hygienists were most likely to refuse while dental hygienists in British Columbia were least likely to refuse to treat clients). The differences between educational groups and provinces may be due to a gap in knowledge about infection control principles and the disease's process. It is important that dental hygienists have adequate knowledge of these topics since they have

an ethical responsibility to treat HIV-positive clients and not doing so can result in charges of discrimination from professional, human rights organizations, or the client.

The research on infection control reviewed in this paper highlights some gaps in dental hygienists' knowledge about infection control, and some gaps between knowledge and practice. The strength of this research is increased with the large quantity of studies and sample size. Although some of the studies include dentists, the results may closely reflect dental hygiene practices since dentists employ the majority of dental hygienists, and they may be following office infection control procedures established by dentists. The weight of the evidence indicates gaps in knowledge and practice and justifies a call for closing and monitoring the gaps.

An impetus for change in knowledge, attitudes and behaviour may need to originate from multiple sources, including the Commission on Dental Accreditation, the National Dental Hygiene Certification Board, dental hygiene organizations, education institutions, and regulatory bodies. There may be a need to revise curriculum to include several new and timely issues — infection control pertaining to private dental hygiene practices, including mobile practices, for example, what is the best method for soaking instruments prior to sterilization when there is no stationary sterilization room to place them? Curriculum can also address informal reports that busy practices sometimes stop sterilization cycles prior to completion of the dry cycle. There is an emerging trend for educational institutions to take leadership in the area of infection control, by requiring mandatory immunization and follow up testing for HBV for dental hygiene students. Dental hygiene regulatory bodies could improve their existing leadership role by following the CDC's recommendations to establish expert review panels to provide counselling to dental hygienists who are infected with HIV or HBV, and to determine under what circumstances they may continue to perform exposure prone procedures. There may also be a need to nurture a culture of infection control within dental hygiene, with assistance from infection control champions to promote implementation in practice settings.

It may be timely for the dental hygiene profession to consider the merits and setbacks of implementing voluntary screening for HIV in dental hygiene settings, particularly given the CDC's call for routine screening in health care settings. The benefits include its cost effectiveness and an opportunity for dental hygienists to make an important contribution to public health by assisting with early identification and reducing high-risk behaviours. However, incorporation of this topic into curriculum may require careful planning, since curriculum may need to include the biological aspects of AIDS/HIV, and the psychosocial aspect of discussing this topic with clients. There is also a need to consider how best to incorporate this into clinical practice, for instance, if consent for HIV testing be obtained with general consent for oral care, how would the referral to a physician be made (the accuracy for the rapid oral testing for HIV is high, but it must be confirmed with traditional testing), and how would a dental hygienist deal with client opposition to the testing or prevention counselling?

The research on DUWL clearly shows a high degree of contamination of and the need to decontaminate the lines with an antimicrobial. Maintaining contamination free lines is important for the health of dental hygienists and their clients, and it may become increasingly important as the population ages and services are provided to a larger number of medically compromised clients. This is particularly important, given that waterlines have been found to contain *Staphylococcus aureus*, which causes an infection, and is resistant to several common antibiotics. The evidence of the high degree of contamination in water lines, and the concerns regarding a lack of compliance with guidelines for infection control raise a considerable degree of concern and point to the need for ongoing education and monitoring of compliance. There is also a need for further research to determine the degree of risk for dental hygienists when they use an ultrasonic scaler.

Preliminary research on DUWL suggests that the size and type of waterline material may affect bacterial growth; however, further research is needed on this topic to confidently recommend these types of lines. Evidence tables 2 and 3 show that although many disinfectants achieve a sufficient reduction in TVC they may not necessarily remove unwanted biofilm from the tubing surfaces, which means that the biofilm will continue to grow and microorganisms will continue to be released into the water. Therefore, it is important to choose a line cleaner that meets two criteria: ability to kill bacteria in the water phase and ability to kill biofilm bacteria.

Out of twenty eight line cleaners, only thirteen reduced both the TVC and the biofilm coverage to a low level (reduction by approximately 94 per cent or greater). These cleaners and the application schedule used in the research are as follows:

- Weekly – Alpron, Sterilox, sodium hypochlorite, Sporkleanz*, Sterilex Ultra*, Dialox, Sanosil*, Oxigenal*, Grotanat Bohrerbad* (*hydroxide-containing products).
- Daily – A-dec ICX (sodium percarbonate, silver nitrate and cationic surfactants).
- Between clients – peracetic acid; and in vitro TAED.

A further study in 2005 concluded that between-client line disinfection is the only way to ensure complete eradication of any microorganisms.[63] Further research on this topic is warranted to determine the most cost effective line cleaner and an appropriate schedule for use.

The research reviewed in this paper did not find a satisfactory in-office kit for testing waterlines. Dental hygienists may need to work together with product manufacturers to develop monitoring kits, solutions for decontaminating the lines, and more clearly define maintenance protocols. The research also indicates that timing and temperature of samples affects reliability of the laboratory analysis. Furthermore, research indicates that waterline samples should be sent to external laboratories immediately following collection by express mail, with a cooling element.

There is some evidence of the link between exposure to airborne bacteria and respiratory disease. However, the evidence from studies on oral health professionals is contradictory. There is insufficient evidence to estimate the risk for dental hygienists who are exposed on an ongoing basis to airborne bacteria. Therefore, further research is

needed on the link between contaminated DUWL and respiratory disease.

Infection control education should provide a clear understanding of the different ways in which organisms are transmitted via aerosols and spatter, and the corresponding prevention strategies for each. Routine treatment of DUWL is needed to minimize or eliminate airborne contamination from the DUWL. Research on HVE, efficacy for reducing spatter is strong and supports their use in dental hygiene practices. Clinical education can assist dental hygienists to become familiar with the devices and techniques that will allow for HVE operation without an assistant. Operators can hold the instrument in one hand and the HVE in the other hand, or use an HVE device that attaches to the operating instrument, such as the ultrasonic scaler, and various "dry field devices" that attach to an HVE.[56]

The exposure to aerosols from clients with pandemic flu is clearly a risk for dental hygienists, as both the CDC and the PHAC have issued directives indicating that if a health practitioner expects to be in close contact (CDC) or performing or assisting with aerosol generating procedures (PHAC) with people who are known or thought to be sick with pandemic flu an N95 respirator should be worn, in the context of an overall respiratory protection program. Dental hygienists may need to discuss the practicality of implementing this directive in their practices. A simplified approach is to defer the clients' appointment if they are thought to be sick with pandemic flu.

There is a need to conduct additional research on aerosols, since there is some indication that they may be present in the operatory for a longer period of time than initially thought — possibly up to 30 minutes following a procedure, and they contaminate a larger surface area than initially thought. Wearing a mask following a procedure for a period of time, and using a client mouthwash prior to treatment are two possible solutions; however, these suggestions require more research to obtain stronger confirmation of their efficacy.

There are several other areas were further research is required. A number of the documents on infection control guidelines reviewed in this paper identify a lack of strong scientific evidence from clinical trials to support infection control procedures. In the absence of clinical trials, the evidence for the recommendations in the guidelines is drawn from respected authorities on the basis of clinical experience, descriptive studies, or reports of expert committees. This research gap underlines the need to conduct rigorous research on the effectiveness and cost effectiveness of infection control. In addition, research suggests that health professionals may be underreporting occupational exposure to HIV and that there may be a discrepancy between Health Canada's reports and Workers Compensation Board reports of occupational acquired HIV. Research in this area is preliminary and there is a need to confirm this information through epidemiological studies.

Infection control should be given high priority in dental hygiene practice, since we live in an age where SARS, avian flu and multiresistant bacteria have international attention. In order to ensure a safe practice, dental hygienists should ensure their infection control practices are current by monitoring changes in infection control practices, engaging in continuing professional development, reading newly published research, and applying evidence based measures. Dental hygienists have a responsibility to keep themselves informed on all infection control topics, and monitor newly published research. Other topics of importance which were not reviewed in this paper and warrant consideration include surgical gloves, latex allergies, hand hygiene, sterilization, environmental disinfection, and disinfection of dental impressions.

RECOMMENDATIONS

Dental hygienists are urged to consider:

- Implementing the CDC's *Guidelines for Infection Control in Dental Health-care settings* (2003). In addition to the CDC's guidelines, it is suggested that dental hygienists follow more stringent guidelines identified in recent literature and in such other guidelines for infection control as the CDC's *Guidelines for the management of occupational exposure to Human Immunodeficiency virus* (HIV)-2005.
- Ensuring their infection control practices are current, by monitoring changes to infection control practices, engaging in continuing education, reading newly published research, and applying evidence based measures.
- Working together with manufacturers to determine cost effective means for testing and maintaining appropriate water standards.
- Choosing a line cleaner (disinfectant solution) that can kill bacteria in the water and bacteria in the biofilm matrix.
- Sending DUWL samples to the laboratory immediately upon collection when using laboratory water testing, by express mail, with a cooling element.

Dental hygiene educational institutions are urged to consider:

- Promoting a culture of infection control.
- Examining curriculum to ensure students receive adequate didactic and clinical experience in infection control, including disease transmission and communicable diseases.
- Informing potential applicants and students in clinical practice that during the course of their clinical education:
  - students will be required to treat patients with infectious diseases (including HIV, HBV and HCV),
  - students with an infectious disease will be required to inform the appropriate authority in their education institution to receive appropriate counselling and specific recommendations.
- Exploring the benefits of modifying curriculum to include HIV screening using rapid oral testing.

Provincial or territorial dental hygiene regulatory bodies are urged to consider:

- Developing standards of practice on infection control.
- Exploring the benefits of mandatory continuing professional development in infection control and practice inspections to assess the level of compliance with guidelines for infection control.

- Establishing expert review panels to provide counselling to dental hygienists who are infected with HIV or HBV, and to determine under what circumstances they may continue to perform exposure prone procedures.
- Conducting ongoing studies to determine if, over time, the gaps between knowledge and practice have narrowed.
- Developing and offering continuing education programs on infection control to increase knowledge and compliance with guidelines for infection control.

CDHA is urged to consider:

- Articulating the ethical responsibility of dental hygienists to treat clients with AIDS/HIV, within the CDHA's *Code of Ethics*.
- Promoting a culture of infection control.
- Developing and offering continuing professional development programs on infection control to increase knowledge and compliance with guidelines for infection control.

The National Dental Hygiene Certification Board and the Commission on Dental Accreditation Canada are urged to consider:

- Examining their role in strengthening the infection control culture within the dental hygiene profession.

Researchers are urged to consider conducting:

- Research to determine the effectiveness and cost-effectiveness of infection control.
- Research on dental hygienists' knowledge of and attitudes towards infection control, and their compliance with guidelines.
- Epidemiological studies to determine more precisely the risk of transmission of bloodborne infections between dental hygienists and clients, and between clients.
- Research on DUWL, including accurate ways for chairside monitoring of bacterial levels in DUWLs, and how the size and type of waterline material impacts on microorganism growth.
- Research to examine work-related risk to dental hygienists' health from a potential long term exposure to *Legionella* and other microorganisms in aerosols.
- Research to determine the degree of risk when using an ultrasonic scaler.

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APPENDIX B
DENTAL HYGIENISTS INFECTED WITH BLOODBORNE PATHOGENS[*, ±]

Purpose

This policy[±] has been developed to:

- Balance the College's mandate of public protection with the rights of dental hygienists infected with bloodborne pathogens to provide dental hygiene care,
- Guide the College's Bloodborne Pathogen and Inquiry Committees,
- Assist an infected registrant with practice modifications or restrictions.

Introduction

Dental hygienists perform invasive "exposure-prone procedures" that present the opportunity for the client to be exposed to the health care worker's blood.[§] Through the strict use of universal infection control precautions, however, the risk of transmission is virtually zero.

Confidentiality

This policy is designed to ensure confidentiality. The identity of an infected registrant need not be known. If known, his/her name will be deleted from documents reviewed by College committees according to current College policies, provided that the infected dental hygienist does not present a risk of harm to the client and is following all recommendations, knowledge of the registrant's identity is not required.

The College's Bloodborne Pathogen Committee will consist of a dental hygienist and other experts, which may include a local public health specialist, an occupational health specialist, an infection control expert, an infectious diseases specialist, and/or an expert in risk assessment, ethics or policy.[§]

Obligations

The College's obligations:

- Establish a Bloodborne Pathogen Committee to make recommendations on and monitor the practice of infected registrants.
- Inform registrants of this policy and encourage all registrants to know their own HIV, HBV and HCV status.
- Strongly encourage all registrants to obtain vaccination against HBV.

Registrant's obligation

A registrant who knows he/she is infected is obliged to contact the Chair of the College's Bloodborne Pathogen

Committee for guidance with his/her practice of dental hygiene. This contact may be in person or anonymously through an advocate or colleague.

Guidelines

1. When a registrant who is infected with a bloodborne pathogen contacts the Committee, the Committee will:

a) Consult with the registrant to:
- confirm the type of dental hygiene being practised, and
- obtain an assessment of the registrant's own infection control standards.

b) Ask the registrant to consult with his/her physician or pertinent health care worker on a regular basis.

c) Recommend practice modifications, if necessary, to help the registrant continue practising.

d) Set up a consultative system with the registrant's health care worker(s) to:
- share information about procedures performed by the registrant and any practice modifications recommended by the Committee,
- share information on the registrant's health status and ability to comply with universal infection control measures.

e) In consultation with the registrant or advocate, select a person as a long term liaison between the registrant and the College. The liaison selected will be a health professional who is familiar with dental hygiene standards of care and practice complexities.

f) Ask the registrant's liaison to:
- encourage stringent standards of care,
- observe the registrant practicing from time to time, to ensure that universal infection control standards are being practiced,
- advise the Committee on the registrant's infection control procedures,
- help the registrant obtain updated infection control information as it becomes available.

g) Establish a regular reporting schedule with the registrant's liaison and advise the Committee on:
- actions the registrant is taking to minimize the risk of transmission,
- any difficulties the registrant is having complying with universal infection control standards,
- details of any exposure incidents.

h) Monitor the registrant's practice of dental hygiene.

i) Monitor any exposure incidents to ensure that recommended infection control protocols are followed to limit the transmission of bloodborne diseases.

2. If the registrant or the liaison becomes aware that the registrant is no longer able to comply with the guidelines, or is no longer able to consistently provide dental hygiene care with a high standard of infection control, or may otherwise be putting his/her clients at risk, the registrant or the liaison will inform the Registrar immediately.

* Bloodborne pathogens include the human immunodeficiency virus (HIV), hepatitis B virus (HBV), and hepatitis C virus (HCV).

± The College of Dental Hygienists of British Columbia. *Registrants Handbook*. 2004.

§ Proceedings of the Consensus Conference on Infected Health Care Workers: *Risk of Transmission of Bloodborne Pathogens*, Health Canada, Health Protection Branch – Laboratory Centre for Disease Control, Canada Communicable Disease Report – Supplement, Vol. 24S4, July 15, 1998.

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