ARTICLE REVIEW

Occupational Exposure and Prevention Guidelines in Dental and Stomatological Settings - A Literature Review

Roberto Manfredi, MD[1]

Summary

A review of the main infectious pathogens potentially transmissible to health care professionals during Dentistry and Odonto-Stomatological procedures is carried out, with particular attention focused on parenteral exposure in the dental, stomatological, and surgical environment. Epidemiological issues and specific risk factors are treated systematically based on available literature sources, together with all available, recommended chemo-prophylactic and immune-prophylactic strategies, as updated by the state of the art in this field.

Key words: Dentistry, Infectious Diseases, Exposure, Professional Risk, Safeguard, Prophylactic Measures.

Introduction

In the Dentistry-Stomatological environment, as well as in the general surgery environment, a number of health care professionals are potentially exposed to multiple occupational infectious diseases. The caregivers of this specific specialty (the so-called Dental Health Care Personnel, or DHCP) include Dentists, Stomatologists, Maxillar-Facial Surgeons, Dental Hygiene Professionals, Nurses and Operative Assistants, Laboratory Technicians, as well as Students, Residents and Fellows in the above-mentioned disciplines. [1, 2]

As it occurs with all other surgical and invasive procedures, the vehicles of occupational infection may be blood or biological fluids containing blood, saliva, respiratory secretions, odontoiatric and surgical instruments, needles, lancets and other sharp instruments, as well as environmental working surfaces, air, and water supplies. [2]

An elevated number of microorganisms are potentially transmissible from patients to health care personnel. [2, 3] The following organisms are of the greatest importance due to their intrinsic frequency or the severity of the eventual occupational infection:

- hepatitis B virus (HBV);
- hepatitis C virus (HCV);
- hepatitis Delta virus (HDV) (only when chronic carriers of HBV are of concern);
- human immunodeficiency virus (HIV);
- Herpes simplex virus (HSV);
- human Cytomegalovirus (CMV);

1 Department of Infectious Diseases, "Alma Mater Studiorum" University of Bologna, S. Orsola-Malpighi Hospital, Bologna, Italy

Correspondencia:
Alma Mater Studiorum University of Bologna c/o Infectious Diseases, S. Orsola Hospital. Via Massarenti, 11 – I-40138 Bologna. Telephone: +39-051-6363355. Telefax: +39-051-343500. Bologna, Italy. E-mail: Roberto.manfredi@unibo.it

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- *Treponema pallidum*, etiological agent of syphilis;
- *Mycobacterium tuberculosis*;
- a number of bacteria, viruses and yeasts which frequently colonize the oral cavity and upper and lower respiratory tract (i.e. Streptococci, Stafilococci, Meningococci, Influenza virus, Parainfluenza virus, Paramyxovirus, Adenovirus, Parvovirus, *Candida* spp., and many others)
- bacteria with a preferential wet habitat involving tanks, containers or wet, wet-hot surfaces, or environmental dust (i.e. Legionellae, *Pseudomonas* spp., *Acinetobacter* spp., *Stenotrophomonas maltophilia*, atypical mycobacteria, fungi, and others); (3)
- from a theoretical point of view, the agents responsible for the Transmissible Spongiform Encephalopathies (TSE), belonging to the family of prions.

The potential pathogenic micro-organism routes of transmission from a patient or his/her body fluids to the health care professional include:

- direct contact with blood, biological fluids contaminated with blood, saliva, or infected respiratory secretions; through percutaneous contact (i.e. accidental needle-sticks or incisions or scratches); through mucosal exposure (i.e. conjunctival, oral, rhinopharyngeal); or through exposure of injured skin;
- indirect contact when health care professionals make contact with contaminated instruments or working surfaces;
- inhalation of micro-drops of saliva or respiratory secretions containing potentially infectious pathogens;
- inhalation of potentially contaminated dust or steam;
- ingestion or mucous contact with contaminated water deposits.

Like every other infectious pathologenesis, it remains strictly necessary that a series of conditions which allow the eventual transmission of microorganisms to the caregivers occur. Among these conditions, we may mention:

- existence of a possible source of infection (the patient undergoing cures, also the health professional him/herself);
- possibility of dissemination of the causative microorganism from the established source of infection;
- existence of a possible transmission route for the eventual pathogenic microorganisms from the established source to the host;
- existence of a reservoir which allows the persistence and the multiplication of microorganisms (i.e. sufficient amount of blood, respiratory secretions, stagnant water);
- sufficient microbial amount to determine human infection;
- sufficient virulence of causative microorganisms;
- presence of a permissive route of entry into the exposed caregiver (i.e. accidental injury, inhalation of biological fluids, interruption of physiological cutaneous barriers);
- availability of a host (the health care professional, in our case), who remains susceptible to the relevant infection (i.e. caregivers not vaccinated in the event of exposure to hepatitis B virus, or HBV).

Microorganisms transmitted by infected blood

When looking into incidence and importance, it is noticed that the main occupational infections occurring in the Dentistry-Stomatological environment (similarly to those occurring in the general surgery environment) are represented by viral hepatitis (hepatitis B and hepatitis C) and by HIV infection (the agent responsible for *the acquired immunodeficiency syndrome,* or AIDS) [1-3], both transmitted by hematogenous spread.

The more common mode of potential contamination of Health Care Personnel by hematogenous-spreading infectious agents is determined by a direct contact with blood or biological fluids containing blood via percutaneous lesions (i.e. needle-stick injury, wounds or scratches caused by lancet of other sharp instruments), the exposure of damaged skin, and the exposure of mucous surfaces (i.e. conjunctives, oral and nasal mucous membranes.) While undamaged skin represents an affordable barrier against all infectious agents transmitted by hematogenous routes, all mucous surfaces (i.e. oral, conjunctival, genital) are more permissive to hepatitis viruses B and C and HIV infection, due to their well known anatomic and physiological features.

However, when assessing the probability of occupational infection risk, we have to take into careful consideration a broad number of epidemiological and pathogenetic variables, which may greatly modify the possibility of effective transmission of infectious agents. Among these last factors, we have to underline the following conditions:

- prevalence of the relevant infection in the local, general population or in individuals who are affected by specific disorders (i.e. greater prevalence of chronic viral hepatitis among haemophiliacs, patients with end-stage kidney disease undergoing haemodialysis, i.v. drug addicts, and institutionalized patients);
- level of viremia in the relevant infected patient (when viral agents with a quantifiable plasma viral load are of concern, like HCV, HBV, and HIV);
- type and frequency of percutaneous or mucous contact(s);
- amount of potentially infectious injected material, or the amount of microbial organisms involved in the accident (infecting microbial load);
- caregiver's susceptibility state and his/her immune defence status.

From an epidemiological point of view, 58% of the Health Care Professionals participating in a survey conducted among 101 Dentistry specialists practicing local anaesthetic procedures in the United States and Canada reported at least one occupational exposure to infectious agents characterized by hematogenous spread during the last six working months. [4] The contacts were predominantly percutanueous in origin (use of intraoral needles and all other sharp odontoiatric instruments.) [4] Assessing the type and mode of exposure to microorganism potentially transmitted by blood, another study conducted in the United States during 11 years, which recorded 208 professional accidents, confirmed that a percutaneous route was greatly prevalent (97.5% of all the cases) compared to mucous exposure (2.9%), and other modes of contamination. [5] A prior surveillance study conducted in the United States from 1987 to 1997 assessed 504 cases of percutaneous exposure occurred in academic Dentistry and Stomatologic environments and classified these accidents as of "moderate" exposure in 52% of the cases, "deep" exposure in 10% of the episodes, and "superficial" exposure in the remaining 38% of the cases. [6] The same paper published by Younai *et al.* [6] underlined that, out of all the exposed personnel, a greater prevalence occurred among students and in-training Professionals (82% of all the accidents) when compared to in-charge "assistants and nurses" (12% of the episodes) and in-charge Dentistry practitioners and Surgeons (only 6% of the cases.) [6] As reiterated later in this review, a particular attention should be paid to in-training Professionals, who often show a less complete technical competence together with a reduced perception of occupational risk.

A relevant Italian epidemiological survey on professional exposure in Dentistry, which is systematically collected and examined by the dedicated "SIROH" Registry (Programma Italiano di Sorveglianza e di Controllo del rischio occupazionale da HIV ed altri patogeni a trasmissione ematica negli Operatori Sanitari, conducted at the "Lazzaro Spallanzani" Hospital of Rome, Italy) recorded over 50,000 accidents occurred in the 1986-2002 period and confirmed that the percutaneous exposure is much more frequent than the muco-cutaneous one (77% *versus* 23% of the episodes), and it also noticed that the situation of index-patients was known in only 28% of the cases before professional exposure. When patients' serostatus was known, the exposure to the hepatitis C virus (HCV) was predominant (63% of the cases), followed by the hepatitis B virus (HBV) (13% of the episodes) and HIV exposure (11% of the cases), while in the remaining 13% of the cases the index-patients had a known co-infection with more than one agent potentially transmissible by an hematogenous route (HCV, and/or HBV, and/or HIV) (personal presentation, Spallanzani Hospital, Rome, Italy, 2006.)

Hepatitis B Virus (HBV) Infection

When assessing the background from an epidemiological point of view, the occupational infection by HBV unfortunately represented a frequent event among health care professionals as a whole. A survey published in 2002 by Siew *et al.* (2, 3) and conducted among United States Dentistry professionals who were examined from 1974 up to 2001 interestingly underlined a progressive drop of serological evidence of HBV infection among health caregivers (from a mean 14% frequency during 1974 down to around 6% in 2001), thus underlying the direct and indirect efficacy of barrier prophylaxis measures, occupational guidelines, and active immunological prophylaxis (mostly represented by the large-scale introduction of anti-HBV vaccination.) (2) According to the same study, in 2001 around 90% of United States Dentistry-Stomatological professionals were already immunized against HBV. [2]

With regard to the HBV infection, the index-case may be represented by a patient with an acute HBV infection or by a subject with a chronic HBV infection (usually easy to demonstrate by a simple search of HBV HBsAg antigen serum.) The route of professional exposure to HBV is represented by parenteral contact (either percutaneos or permucous) with blood, biological fluids containing blood, or saliva. The risk of occupational transmission of HBV is up to ten-fold greater when the index-patient proves positive at the search of serum antigen "e" (HBeAg), or he/she is viremic (i.e. the patient has a positive quantitative assay of HBV-DNA levels measured using PCR techniques.) Among health care professionals who are not vaccinated for HBV or were not responsive to the HBV vaccine (i.e. did not reach a sufficient antibody level after a specific vaccination), the risk of transmission after percutaneous exposure ranges from 6% to 30% of the cases, with the greatest risk when index-patients are HBeAg positive (37% to 62%) compared to index-patients who test HBeAg negative (23% to 37%.) [7]

With regard to the delivery mode of post-exposure prophylaxis for HBV based on the recommendations from the United States Center for Disease Control (CDC), updated in 2003 [2, 7], the situation of each single caregivers and each single index patient must be preliminarily assessed as summarized in Table 1.

Finally, the theoretical possibility of transmission of viral hepatitis B (HBV) from a Dentistry professional to a patient occurred in nine different mini-clusters documented in the United States from 1970 to 1987, when a confirmed HBV infection occurred in pa-

Table 1. Viral Hepatitis Type B (HBV). Guidelines for Occupational Post-Exposure Prophylaxis

Health care professional	Patient	
	HBsAg positive	***HBV laboratory issues unknown***
Not vaccinated for HBV	Anti-HBV immunoglobulines*, + plus complete cycle of anti-HBV vaccination (three dosages)	Complete cycle of anti-HBV vaccination (three dosages)
Effectively vaccinated for HBV		
- with serum HBsAb antibody levels >10mIU/mL (protective levels)	Nothing	Nothing
- with serum HBsAb antibody levels <10mIU/mL (non-protective levels)	Anti-HBV immunoglobulines*, + plus complete cycle of anti-HBV vaccination (three dosages) (if a prior vaccine cycle was not completed) Anti-HBV immunoglobulines*, with a second administration after 30 days (if a prior vaccine cycle was carried out, but the health care professional proved to be a "non-responder" to the anti-HBV vaccine)	As in the case of a patient with a known HBsAg positivity, if an elevated risk of HBV infection is of concern

tients cured by health care professionals who were chronic HBV carriers. [(2)] Since 1987, the United States CDC has not reported further episodes. Therefore, this last occurrence is presently estimated to occur at an extremely reduced (virtually negligible) rate. [(5)]

On the other hand, during 2003 an anecdotal accident which led to the transmission of HBV from one patient to another was described in an Odontostomatological medium. [(2)]

Hepatitis C virus (HCV) Infection

The prevalence of chronic HCV infection among health care professionals is not significantly different compared to that of the general population (around 1%-2% of the examined caregivers.) [(2, 8)] As it is well known, the elevated diffusion of HCV infection, its high rate of chronicization (around 70% of the cases), and the very frequent lack of a clinical history of the acute (i.e. icteric-symptomatic) phase are still underestimated in the general population; therefore, only anecdotally retrieved serum liver enzyme alterations lead to the (often late) recognition of an underlying chronic, but missed, HCV infection which often has progressed towards a more advanced hepatic disease stage in a significant percentage of the cases.

In a literature survey conducted in a Dentistry environment and based on 49 patients who tested HCV-RNA plasma positive (i.e. positive HCV viremia, as assessed by a molecular biology technique of polymerase chain reaction or PCR), HCV-RNA proved present in saliva in 35% of the cases, while this percentage rose to 41% when gingival interstitial fluid was examined. [(9)] In 135 interviews conducted in Australia regarding the management of different Odontostomatologic procedures, dental extraction proved to be the main determinant of health care professional iatrogenic exposure of to HCV-infected patients (85% of the cases), followed by surgical procedures carried out under general anaesthesia (82% of the episodes), surgery performed under local anaesthesia (76% of the cases), and complex Odontoiatric-Stomatologic procedures (35% of the episodes.) [(10)]

In any respect, the comprehensive risk of HCV occupational transmission is considered quite low; for example, until 2002 only four anecdotal cases of anti-HCV seroconversion were registered among Dentistry practitioners in Italy, two of them occurred after conjunctival contamination with infected blood (11) and another episode after blood contact with non-undamaged skin. Needle-pricking with contaminated injection needles represents the most relevant professional risk factor for Odontostomatologic personnel (2, 8) as well as for caregivers as a whole. The mean risk of HCV transmission after percutaneous exposure is estimated at around 1.8% of the cases (range 0-10% of all cases) based on the available literature evidence. (2, 7, 8, 12)

During a recent survey performed among 267 Brazilian Dentistry professionals, it was found that a worrying lack of awareness regarding the risk of exposure to HCV (and other blood-borne microorganisms) was evident in the great majority of health care personnel; fortunately the prevalence of HCV infection among caregivers was extremely low (0.4%) compared to that of the general population. (13)

Taking into account that at this time we lack both effective active and passive immunoprophylactic strategies against HCV (neither vaccines nor immunoglobulines are available), the recommended procedures after a professional accident occurs with confirmed HCV infected patients should include: (8)

- screening of anti-HCV serology at baseline (mostly for medical-legal-insurance purposes);
- repeated testing of anti-HCV serology after 3-4 and 6 months;
- eventual search of plasma HCV-RNA (by a PCR technique) to be performed at least 4 and 6 weeks after the occupational exposure;
- quantification of plasma HCV-RNA viral load becomes mandatory should primary HCV infection be detected;
- eventual pharmacological anti-HCV treatment may be considered (under experimental basis, at this time) in order to try to reduce the risk of chronicization in the recently seroconvert health care personnel should HCV quantitative viremia also test positive. (2, 8, 14)

Human Immunodeficiency Virus or HIV Infection

As it happens in the event of exposure to the hepatitis C virus (HCV), no active and passive immunoprophylaxis measures exist in the event of occupational exposure to HIV-infected patients.

Until 2001, a conscientious United States registry documented 57 cases of HIV infection presumably acquired by occupational exposure among health care workers, but no episode was registered in the Dental-Odontostomatological environment. (2) In any event, the risk of occupational transmission of HIV infection is deemed to be very low; it is estimated at an average of 0.3% (range 0.2%-0.5%) in the event of accidental percutaneous injection, at around an average of 0.1% (range 0-0.2%) when mucous exposure is of concern, and it is virtually absent in the event of exposure of non-undamaged skin. Since these data were collected before the introduction of more potent and combined antiretroviral therapies (cART) (from 1986 to 2002) (2), it may be estimated that a further reduction of risk of transmission should stem from the expanded use of the present, highly active antiretroviral therapy (HAART) combinations, which have been widely diffused in the industrialized world since mid-1996 (12 years ago) given their established efficacy.

Although not in highly infectious concentrations, HIV is however retrievable in oral fluids, as demonstrated by the possibility to collect a dosage of viral load (either HIV-RNA or HIV-DNA) in saliva from 5% to 44% of the subjects with the HIV disease. Such an oral viral load, although proportional to plasmatic levels, remains much lower than that concurrently measured in patients' serum and around 3-fold lower compared to that measured in semen using the same laboratory techniques. As expected, the levels of salivary HIV viral load may increase in the presence of local inflammatory disorders, like gingivitis, parodontopathy, stomatitis, mouth and lip ulcerations, and even more should hemorrhagic facts be of concern. The proportionally low levels of HIV salivary virus concentrations, together with the local presence of natural substances able to inhibit the HIV Retrovirus (i.e. the secretory leukocyte proteinase inhibitor or SLPI, the lisozyme, and numerous other defences), continue to support the concept that saliva per se cannot be considered and is not presently referred to as a vehicle of HIV infection during health care. [2, 15, 16]

In any case, it remains known that the factors eventually supporting an increased risk of HIV infection transmission to health care personnel are associated with one or more of the following conditions: [19]

- needle-pricking with a hollowed needle;
- deep injury;
- exposure to an elevated volume of patient's blood;
- accident occurred with a needle or other sharp instrument, which appeared visibly contaminated with the index patient's blood;
- injury occurred with a needle directly positioned in a vein or artery of the HIV-infected patient;
- exposure to a patient with an advanced, uncontrolled HIV disease (i.e. full-blown AIDS) and/or to a patient who is not under any antiretroviral therapy or has an ineffective ongoing anti-HIV treatment (i.e. when viral resistance to drugs is present), or to all conditions which may support greater plasma levels of HIV-RNA (viral load) and an increased patient's infectivity.

Interesting epidemiological data are available from the United States registry of post-exposure prophylaxis regarding all the cases of accidental caregivers' exposure. In a three-year period (1996 to 1998), around 60% of the index patients, among 492 cases of documented professional exposure to HIV, had a known HIV infection. [17] Percutaneous injuries largely predominated over mucous-cutaneuous ones (85% *versus* 10%), while causative biological fluids were represented by blood in 71% of the episodes, followed by other biological fluids containing blood in 13% of the cases. At the time the study was under way, a triple drug combination (three different, associated antiretroviral agents given simultaneously) was carried out in 59% of the cases related to health care professionals who underwent a pharmacological prophylaxis, while a dual combination was delivered to 36% of the exposed subjects within a very short time interval after the accident (median time: 1.8 hours.) [17] Even though the early interruptions of antiretroviral prophylaxis were remarkably frequent (around 54% in this study, taking into account the standard, recommended duration of antiretroviral prophylaxis still fixed at 30 days) among health workers, no case of HIV transmission to exposed personnel occurred after adequate, repeated serological controls. [17]

When focusing specifically on Odontoiatric-Stomatological personnel, 208 cases of accidental exposure were registered in the United States from 1995 to 2001. [5] Risky procedures were predominantly represented by percutaneous exposure, with the involvement of hollow needles in the majority of the events. Index patients had an already known HIV infection, or it was subsequently ascertained in only 53 cases (37% of all the episodes.) A post-exposure pharmacological prophylaxis has been conducted in 24 Dentistry professionals with three associated antiretroviral compounds (cART) during a period ranging from 5 and 29 days; no case of HIV seroconversion has been registered among the whole cohort of 208 involved health care professionals. [5]

In Italy, the pharmacological prophylaxis of professional contacts with HIV-infected patients or subjects suspected to be HIV-infected is periodically updated by a branch of the Italian Ministry of Health. The main recommended indications for an anti-HIV combined pharmacological prophylaxis are the following:

- accurate clinical history of the exposed caregiver and detailed report of the professional accident dynamics;
- release of a written informed consent preceded by adequate counselling performed by the reference Infectious Disease specialists, who are available through Emergency consultation 24 hours a day;
- timely initiation of anti-HIV drug prophylaxis (preferably within 1 to 4 hours after the accident.) Such a pharmacological intervention is no longer recommended if more than 72 hours have elapsed since the occupational exposure;
- accurate selection of drugs, their combination and their dosage, which reproduce the potency and efficacy of those proposed by the most recently updated guidelines for HIV infection treatment (three-drug antiretroviral regimens, or cART); [18]
- four consecutive week duration of occupational chemoprophylaxis, with periodical haematological-biochemistry laboratory controls (to be performed at the baseline every 10 days during the pharmacological prophylaxis.)

The widely applied guidelines for post-exposure prophylaxis after an accident possibly involving HIV-infected index patients are stratified according to the mode of exposure and the known conditions of index patients [18] as briefly summarized in Table 2.

Since the early introduction of highly active antiretroviral therapy (so-called HAART), which was available in mid 1996, the majority of HIV-infected individuals (presently around 80% of them) is treated with a cART, usually including at least three different, associated antiretroviral molecules. The availability of HAART, while significantly modifying the natural history of the HIV disease and leading to a sharp drop of morbidity and mortality rates, concurrently contributed to a progressive increase of emerging and spreading drug-resistant HIV viral strains, which often become unresponsive to divers drugs and multiple drug classes. This last situation leads to a prompt consideration of resistance when post-exposure prophylaxis has to be considered, so that a "standard" combination or a regimen selected on the ground of eventual needs of the exposed caregiver (i.e. tendency to develop anaemia, eventual kidney or liver abnormalities, ongoing pregnancy, and so on) is now replaced by regimens which should be "tailored", as

Table 2. Health Care Professional Post-Exposure Chemoprophylaxis for HIV Infection (2008)

Mode of exposure	Post-exposure prophylaxis
- injury caused by needle or other sharp instruments	- recommended
- conjunctival contamination	- recommended
- non-undamaged skin or mucous contamination	- to be considered
- wound caused by human bite	- to be considered
- contamination of non-undamaged skin	- not recommended
Index patient	**Post-exposure prophylaxis**
- patient with known HIV infection positivity	- recommended
- patient with unknown situation regarding HIV infection, or subject who reports to be HIV negative	
- patient with unknown situation regarding HIV infection or whose situation data are not available at the time of accident	- to be considered
- patient with a known negative HIV testing	- not recommended

much as possible, on the cART performed by the index patient, the levels of patient's adherence to his/her prescribed cART, the level of attained virological-immunological success, and eventual information regarding suspected or established viral HIV resistance to drugs administered during the patient's lifetime. The epidemiological survey conducted at the time of occupational exposure should therefore include (when possible) awareness of antiretroviral drugs taken by the index patient at the time of the accident, their efficacy (depending on measured plasma HIV-RNA levels), the extent of the patient's compliance to recommended therapy (since a low adherence may support the emergence of viral resistance), and the eventual availability of pharmacological HIV resistance testing. [19, 20]

An anticipated anti-HIV drug prophylaxis, when indicated after a risky professional exposure, is still recommended to be 30 day long, although it seems intuitive that the maximum protective activity is concentrated during the first hours and the first day after exposure to HIV infection; hence the importance of starting prophylactic measures as soon as possible. Infectious Disease specialists are committed to the selection (and eventual modification) of a specific pharmacological regimen, as explained above, among over 20 different antiretroviral drugs presently available. The treatment protocol should be illustrated and shared with the exposed caregiver, and the subsequent clinical and laboratory monitoring should be carefully planned.

Finally, a short notation on the virtual possibility of HIV infection transmission from the health care professional to his/her patients, which is estimated to be an extremely rare event, was stressed by an anecdotal report which shed light on a probably voluntary spread of HIV infection to a group of six patients occurred in Florida (USA) in 1990 by a single Dentistry specialist (the so-called "Kimberly case"), whose documentation was based on the analysis of the viral genomic sequence which proved to be the same in the caregiver and in the six infected patients. [21]

Microorganisms transmitted by saliva and respiratory secretions

This broad category of microorganisms includes some pathogens which could be harmful in the event of occupational exposure like *Mycobacterium tuberculosis*, Streptococci and Staphyilococci, *Neisseria meningitidis*, Influenza and Parainfluenza viruses, Herpes simplex virus (HSV), Cytomegalovirus (CMV), Epstein-Barr virus (EBV), Adenovirus, Rhinovirus, Paramyxovirus, and Rotavirus. [22, 23]

The potential routes of transmission from patients to health care professionals include contacts with respiratory secretion saliva. This could occur by direct contact, indirect contact, and by inhaling the secretion. Factors which may influence the risk of occupational transmission include the prevalence of infection(s) in the general local population, the microbial load retrievable in respiratory secretions, the way of spreading respiratory secretions (i.e. cough, sneezes), the presence of potential vehicles of transmission (i.e. instrumentation, working surfaces, dust, aerosol), the virulence degree of eventual causative microorganisms, the amount of infected material responsible for occupational exposure (infecting load), as well as the degree of susceptibility and the immune state of the host (health care professional in this event.) All these conditions may play a significant role and should be carefully considered.

A short reference is dedicated to respiratory tubercular infection.

Tuberculosis

As a consequence of the recent epidemiological mutations which involved the majority of developed countries, *Mycobacterium tuberculosis* shows an increasing importance in the general population and even more among subjects which are immune-compromised at some degree. [24, 25]

Patients with active clinical pulmonary or laryngeal tuberculosis may spread mycobacteria via the droplets of respiratory secretions (diameter: 1-5 μm) diffused after coughing or sneezing. These particles may remain in suspension in the room air for a number of hours, and the particular wax-including cell walls of mycobacterial organisms support their slow ground landing. Moreover, mycobacteria may survive in the environment (i.e. dust) for weeks or even months, and may be transmitted to a susceptible host by inhalation even after an apparently prolonged time.

In the Dentistry-Stomatological practice, only one case of occupational tuberculosis was documented in the United States up to 2003 (15, 24); therefore the risk of transmission of this mycobacterial disease from a patient to Odontoiatric caregivers by inhalation is estimated to be very low, as indirectly confirmed by a low rate of positive tuberculin skin testing (Mantoux intradermal reaction) among Odontostomatological personnel as a whole. [5, 22, 25]

As it is the case for any other health care professional, the control measures for occupational transmission of tuberculosis include the implementation of a targeted epidemiological and clinical surveillance, an early recognition of patients with active pulmonary tuberculosis and their appropriate isolation, an adequate caregiver education and training with regard to the systematic use of filter-equipped facial masks (N-95 model) when a suspected case is of concern [22, 25] (refer to Table 3), and the timely assessment of exposed personnel who show some suspicious signs and symptoms (i.e. persisting cough for at least three weeks, with or without fever, anorexia, asthenia, night sweats, weight loss, and eventually haemoptysis.) When urgent Odontoiatric-Stomatological care has to be delivered to patients with active bacillary lung tuberculosis, the assistance should be delivered in an appropriate environment guarantying respiratory isolation (rooms with adequate filtering and air volume turnover for an established period of time) and making strict use of all individual protection devices including disposable gloves, glasses, protective gowns, and facial masks with type N-95 filters. (15, 25) As it is well known, the common surgical masks do not ensure protection against transmission of respiratory tuberculosis to other patients and health care personnel.

Microorganisms transmitted by water

Water reservoirs and pipelines which conduct water supplies (i.e. irrigators, pipes, syringes, tartar ablators) may be easily colonized by bacteria, fungi, and protozoa (sometimes able to overcome some common disinfection procedures.) In particular, bacteria tend to adhere and grow on the internal surface of pipes, often protected by a polysaccharidic layer (which is part of the superficial glycocalix of a number of bacterial species.) As a consequence, a bio film which continuously increases the resident bacterial population is typical of superficial waters, and this bacterial reservoir may be transmissible to patients and health caregivers, too. [5] In the majority of cases, saprophytic or commensal organisms are of concern because they may become frankly pathogenic when subjects with underlying, chronic, severe disorders;

Table 3. Individual Safeguard Devices to Be Used Appropriately

Individual safeguard devices	Characteristics
Disposable surgical mask protecting both nose and mouth	It provides protection against particles whose size (diameter) is greater than 5 μm
Type N-95 facial mask (filter-equipped)	It provide protection against particles whose size (diameter) is lower or equal to 5 μm
Protective eyeglasses	
Disposable protective gowns	
Disposable gloves	Always to be employed when surgical procedures or other invasive medical interventions are carried out.

immunocompromised hosts; or subjects with damaged cutaneous/mucous barriers are assisted.

Among the numerous microorganisms which are potentially present in devices which contain or convey water, the following are the most frequent and/or the most relevant to human pathology: ([3, 23])

- *Legionella* spp.;
- *Pseudomonas aeruginosa* and *Pseudomonas* spp.;
- Non-tuberculosis mycobacteria (so-called “atypical mycobacteria”);
- *Shigella* spp.;
- *Acinetobacter* spp.;
- *Stenotrophomonas* (formerly *Xanthomonas*) *maltophilia*;
- *Guardia lamblia*;
- *Cryptosporidium parvum*.

The transmission route of the above mentioned microorganisms spread in superficial water involves the ingestion of or a direct contact with water, contact with contaminated instrumentation, and inhalation of aerosolized particles. Dental procedures performed with high-speed instruments tend to expose health workers to possible splashing in nearly 90% of the cases, and over 50% of the stains are invisible to the naked eye according to 2008 studies. [(26, 27)] In particular, contamination of both air and surfaces by blood particulate may reach 100% of the cases should procedures leading to extensive aerosols of body fluids be performed.

Some surveillance studies carried out on health care personnel of Odonto-Stomatology units located in different geographical areas have demonstrated alteration of resident nasal flora as well as an increased prevalence of positive serology against *Legionella* spp. when compared with the general population. From a practical point of view, only anecdotal reports of documented occupational infection cases caused by these pathogens have been registered; the majority of these episodes involved subjects with some form of immunodeficiency and an elevated level of microbial concentration in examined water sources (over 500 CFU/mL.) (*Center for Disease Control*, and *American Public Health Association*, 2003) [(3, 7)]

In terms of legionellosis, a specific survey has been conducted in 28 United States Odontostomatology studies: a combined examination of water reservoirs and water distribution pipes led to the retrieval of specimens positive for *Legionella* spp. in 32% of the cases and for *Legionella pneumophila* in 92% of the specimens examined with a direct immunofluorescence technique and/or PCR. [(28)] In the same study, the concentration of Legionellae in water reservoirs and mains tested particularly high (above 1,000 CFU/mL) in 36% of the events when *Legionella* spp. was retrieved. [(28)]

When considering *Pseudomonas aeruginosa*, the last gram-negative organism (dangerous due to the severity of respiratory and urinary tract infection and its frequent, enlarged antibiotic resistance pattern) has been retrieved in 5.5% of the water supplies examined during a Danish study performed in 327 different reservoirs and distribution pipes of a large number of Odontoiatric-Stomatologic sites and clinic facilities. (29) However, the possibility of nosocomial transmission of *Pseudomonas* spp. to patients undergoing dentistry-stomatological cures remains low, as suggested by an anecdotal 1996 report, when one single case of *Pseudomonas aeruginosa* pneumonia in a highly predisposed patient suffering from cystic fibrosis, who had previously undergone dental extraction, was reported Denmark. (29) The authors documented a genotypic relationship between bacteria isolated from respiratory secretions of the involved patient and those retrieved from water and instrumentation of the Odontoiatric clinic where the dentistry intervention had been performed. (29)

In order to increase the safety index of instrumentation containing or working with water supplies, usually employed in Medical and Odontoiatric-Stomatological studies, the United States Center for Disease Control has issued the following recommendations (3, 7) which, from a practical point of view, appear to be useful:

- let the water run freely for a sufficient period of time before using instrumentation and devices at the beginning of each work day;
- employ chemical-physical treatments for basic water disinfection;
- make systematic use of appropriate micro-filters;
- make systematic use of anti-reflow valves in order to avoid any sort of water stagnation;
- follow adequate hygienic procedures during patient treatments (i.e. let run both air and water freely for at least 20 to 30 seconds);
- rely on sterile water or saline solution during all surgical procedures;
- periodically monitor the bacterial concentration in reservoirs, water pipes and mains of all places where Dental and Odonto-Stomatological procedures are practiced.

Other infections potentially related to occupational transmission routes

Transmissible spongiform encephalopathy

Transmissible spongiform encephalopathies are neurodegenerative disorders characterized by a rapidly progressive and fatal evolution which may involve animals and humans and are caused by protein-composed infectious agents (the so-called "prions"), which are highly resistant to the common disinfection and sterilization procedures. Not transmissible by aerial route, these diseases are generally classified into animal spongiform encephalopathies (scrapie, mink encephalopathy, feline encephalopathy, exotic ungulate encephalopathy, elk devastating encephalopathy, and bovine spongiform encephalopathy, the so-called "mad cow disease", or BSE) and human encephalopathies (Kuru, Gerstman-Straussier-Scheinker disease, familiar fatal insomnia, Creutzfeld-Jacob disease, and the so-called "novel variant" of Creutzfeld-Jacob disease.) (30)

The human spongiform encephalopathy of potential iatrogenic interest is the Creutzeld-Jacob disease, which is nosographically classified into variants:

- sporadic form (responsible of around 85% of the observed episodes);
- familiar form (found in around 10 to 15% of the cases);
- possible, rare iatrogenic forms, potentially transmissible through neuro-surgical instrumentation and contaminated intracranial electrodes, hypophyseal hormones extracted from affected patients, and implants of cornea or dura matter obtained from patients deceased due to Creutzfeld-Jacob disease.

As it is widely known, the so-called "new variant" of the Creutzfeld-Jacob disease has been detected and investigated since 1996. It is transmitted from bovines to humans, mostly by the alimentary route. [30]

The epidemiological data available to date does not demonstrate the transmission of these spongiform encephalopathies during Dentistry and Odontostomatological procedures. Furthermore, infectious prions were not found in blood, saliva, oral cavity tissue, and dental pulp of patients affected by a confirmed Creutzfeld-Jacob disease [22, 23, 31]; therefore the risk of transmission associated to Odonto-stomatological procedures is deemed to be extremely low. [22] In any event, when suspected cases are of concern, disposable instruments should be used and extremely potent sterilization procedure applied (i.e. NaOH 1-normal solutions for at least one hour, followed by an autoclave exposure at 134-138°C for at least 20 minutes.)

Occupational infection prevention strategies

The interruption of potential infection transmission processes plays an absolutely crucial role when assessing health care professionals' prevention and safeguard procedures. [1-3] These strategies include:

- adoption of appropriate environmental hygienic standards;
- application of adequate personal hygiene and security measures;
- containment of unexpected "breakdown" risks indirectly connected to logistics and organizational problems, overcrowding, and so on;
- correct and constant use of individual protection devices (24) (i.e. masks, eyeglasses or visor masks, gloves);
- systematic application of adequate disinfection and sterilization procedures on all instrumentation;
- maximum attention paid to needle and disposable sharp instrument collection and elimination procedures (i.e. resort to rigid containers, incineration procedures, and so on);
- application of aseptic assistance techniques and procedures;
- systematic use of liquid/air aspirators (in order to minimize the formation of aerosolized biological fluids);
- permanent epidemiological surveillance and standardized monitoring of eventual professional accidents;
- implementation of periodical health care worker screening procedures and early diagnosis of patients with suspected infections and transmissible diseases;
- rely on all possible strategies of immunoprophylaxis (i.e. wide use of available vaccination procedures.)

In fact, when considering that most of the patients with infectious disorders potentially transmissible to health care personnel who require Dentistry and Odonto-Stomatological interventions are asymptomatic or paucisyntomatic, it may frequently happen that these subjects ignore or voluntary hide the fact from assistance staff. As a consequence, it becomes mandatory to always consider blood and biological fluids as potentially infected or infectious. It is therefore necessary to systematically apply the standard safeguard procedures to any kind of parenteral contact with blood and biological fluids (i.e. saliva, respiratory secretions, biopsy specimen) and to appropriately protect non-undamaged skin and mucous surfaces (i.e. conjunctives, oral cavity and nasal mucous membranes.) Finally, it always remains useful to remember the crucial importance of careful and frequent hand washing with water and soap or antiseptic solutions both before and after using gloves.

All Dentistry-Odontostomatological instrumentation (and all non-disposable surgical instrumentation as a whole) needs careful cleansing and sterilization. All health care professionals who are in the Dental-Stomatological specialties and sub-specialties are and should be considered surgeons called to perform potentially invasive procedures.

With regard to the potential risk of infectious agent transmission, Odontostomatological instruments (and surgical instruments as a whole), may be classified as:

- critical, for instruments able to penetrate bone and soft tissues;
- semi-critical, for relevant instruments that do not penetrate body tissues but have contact with superficial mucous membranes;
- not critical, for instrumentation exclusively used over undamaged skin surfaces.

As anticipated, the prompt availability and the systematic and correct use of all individual protection devices (also defined as personal protective equipment, or PPE) play a fundamental role during clinical procedures which encompass a potential exposure to blood, body fluids, or secretions even when they are dispersed in an aerosolized form. The different devices to be employed according to the different clinical scenarios are briefly summarized in Table 3, together with their most relevant characteristics.

A recent survey regarding the resort to individual protective equipment conducted in Parma (Italy) through 122 interviews with Dentistry specialists demonstrated these health care professionals' high awareness of the protection against occupational infectious diseases problem. [30] In fact, this study demonstrates that, of all caregivers potentially exposed to body fluids, 98% regularly wear gloves during medical and surgical Dentistry-Odontostomatologic procedures, 95% regularly wear masks, and 94% wear eyeglasses. [2]

During a series of recent interviews carried out in a qualified, academic Odontoiatric-Stomatological environment in Palermo (Italy), it was observed that the exposure risk to an hepatitis B infection and the degree of HBV vaccine coverage were inversely proportional to the level and duration of professional practice [20], thus underlying that students, trainees, and residents may be exposed to high risks and that an appropriate counselling and training aimed to increase awareness of these relevant problems is still strongly needed. [31] In fact, two recent United States surveys [32, 33] underlined that, just during their program courses and practical training, students or trainees tend to underestimate the risks and problems related to professional exposure as a whole and also to dismiss "accident" reports (generally needle-pricking or other instrumental injuries) since they deem these events irrelevant (around one third of the cases.) [33] The frequency of underreporting was greater in male health care workers [33] and also during the first years of study and professional training. [32, 33]

In the event of a professional accident, we underline the need to always pursue the following directives, notwithstanding the various recommendations reported above which must be scheduled according to the different potential causative pathogens: [2, 3]

- when a percutaneous lesion is of concern, it is necessary to carefully wash the exposed area with water and soap or disinfectant solutions;
- in the event of exposure of non-damaged skin to blood and/or biological fluids, it appears sufficient to carefully wash the exposed area with water and soap or disinfectant solutions;
- when a conjunctival exposure to blood and/or biological fluids is of concern, we recommend washing and rinsing the eyes with water and saline solutions;
- in the event of oral contact or ingestion

of blood and/or biological fluids, it is necessary to immediately wash and rinse the oral cavity with water and saline solutions repeatedly;
- in every case, it is recommended to prepare and fill out an accurate report indicating location, date, and time, type of professional exposure, name of index patient, immunoprophylactic situation of the involved health care professional, adopted procedures, and scheduled follow-up;
- professional accidents should be reported according to the different rules provided by National Health Services;
- all measures of microbiological diagnosis and post-exposure prophylaxis (i.e. serological controls, vaccinations, immunoglobulin administration, pharmacological chemoprophylaxis, and so on) should be performed in the event of an accident and according to the recommendations proposed above, which follow the updated international recommendations in this field;
- internal guidelines which establish an univocal pathway and offer a more suitable, easily recognizable, and more rapid algorithm for the health care professional involved in an accidental exposure should be implemented and continuously updated based on current regulations, the evolution of scientific knowledge, and the local competence and responsibility network (i.e. involvement of Emergency Rooms, Occupational Medicine, Preventive Medicine, Infectious Diseases, Microbiology, and so on.)

As plentifully presented above and according to the United States Center for Disease Control recommendations, all health care personnel working in the Dentistry-Odontostomatological environment should receive the following active immunoprophylaxis measures (vaccinations) if specific contraindications are absent:
- type B hepatitis (HBV);
- measles, rubella, and epidemic parotitis;
- Influenza virus;
- Varicela-zoster virus.

Conclusions

All data regarding the potentially accidental exposures to pathogens should be reliably collected and periodically monitored and analyzed in each academic and professional institution, and this appears to be also mandatory in the Dentistry-Odonstostomatology field. The objective is to establish a permanent control with regards to the adoption of all the recommended protection measures and prophylactic strategies and the observance of international and local guidelines in this field in order to ameliorate patient cure rate, to strengthen the training process of all future health care workers, and also the management of professional risk due to accidental exposure to pathogenic microorganisms. A systematic collection and analysis of all updated, available data may be a solid basis for assessing the exposure type and location, time variation, involved caregivers, their training and competence degree, and trust in the appropriate and timely adoption of all specific recommendations in this area. On this ground, the possibility to predict and prevent professional exposures to infectious agents is expected to increase by implementing a uniform educational pathway toward technical-practical knowledge. The latter must enter the heritage of theoretical and technical-practical knowledge as part of the educational process delivered by any recognized and certified academic and professional institution.

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