**SUPPLEMENTAL INFORMATION**

***Legionella* in dental offices: Critical review and modeling case study quantifying aerosol risks to dental workers and patients**

**Supplemental Table S1** Management actions associated with lowering the occurrence of, and/or exposure to *Legionella* spp. or other opportunistic pathogens in dental office water systems

|  |  |
| --- | --- |
| **Management action** | **Reference** |
| Using distilled or sterile water in the dental waterline; however, this will not eliminate bacterial contamination if waterline biofilms are not effectively controlled. Sterile solutions (sterile saline or sterile water) should be used as a coolant/irrigation in the performance of oral surgical procedures. Ensure only heat-sterilized/sterile-disposable bulb syringes or sterile water delivery devices are employed to deliver the sterile water. | 20,27–29 |
| Use a small pore size filter (e.g. 0.22 micron) in-line or at taps. | 20,29,30 |
| Flushing dental unit water lines at the beginning and at the end of the day for a few minutes, as well as after each patient, although this does not remove the biofilm. Dental devices that are connected to the dental water system and that enter the patient’s mouth (e.g., handpieces, ultrasonic scalers, or air/water syringes) should be operated to discharge water and air for a minimum of 20–30 seconds after each patient. | 20,27,29,31 |
| Avoid heating dental unit water for patient comfort unless high heat treatment used for remediation. | 28 |
| Biocides, disinfectants, UV, or heat treatments can be used to sterilize dental handpieces and other intraoral devices attached to air or waterlines. Manufacturer’s instructions for cleaning, lubrication, and sterilization should be followed to avoid equipment damage. Do not surface-disinfect, use liquid chemical sterilants, or ethylene oxide on handpieces and other intraoral instruments that can be removed from the air and waterlines of dental units. Dental components that cannot be removed for cleaning should be covered with impervious barriers that are changed after each use. If the item becomes contaminated during use, an EPA-registered intermediate hospital disinfectant should be used before the next use. | 20,29,31,32 |
| Personal protective equipment such as gloves and face masks are designed to protect individual healthcare personnel and must be used in practice. | 31 |
| Dental health care professionals should be trained regarding water quality, biofilm formation, water treatment methods, and appropriate maintenance protocols for water delivery systems. Monitoring of water quality can be performed to validate protocols and can be performed as recommended by equipment manufacturers using commercial self-contained test kits or commercial water-testing laboratories. However, monitoring for specific organisms is not typically recommended except in the case of a suspected waterborne disease outbreak. | 30,31 |
| During a boil water advisory, water should not be delivered to patients through the dental unit, ultrasonic scaler, or other dental equipment that uses the public water system. Patients should rinse with bottled or distilled water until the boil-water advisory has been canceled. Do not use tap water to dilute germicides or for hand hygiene unless it has been boiled for ≥1 minute and cooled before use; non-water antimicrobial hand-rubs or antiseptic towelettes can be used in the interim. After the advisory is canceled, the local utility should provide guidance for flushing of waterlines to reduce contamination (approximately 1 to 5 minutes although there is no consensus). After flushing, dental unit waterlines should be disinfected according to the manufacturer’s instructions | 31,33 |
| Use of anti-stagnation or continuous circulation measures to reduce stagnation in dental water systems. | 20 |
| Consider using separate water reservoir system to eliminate the inflow of municipal water into the dental unit. | 28 |
| If recommended by manufacturer, install antiretraction valves to prevent oral fluids from being drawn into dental waterlines. | 28 |
| Only qualified maintenance personnel should service and/or decommission dental chair units. | 27 |
| Water in routine dental procedures should comply with current drinking water regulations (fewer than 500 CFU/mL heterotrophic bacteria). | 31,34 |
| Do not advise patients to close their lips tightly around the tip of the saliva ejector to evacuate oral fluids. | 35 |
| **COVID-19-issued guidance related to incidental water/aerosol exposures:** Minimize use of air-water syringes. The use of ultrasonic scalers is not recommended during this time. Prioritize minimally invasive/atraumatic restorative techniques (hand instruments only. Screen for dental emergencies using teledentistry. If aerosol-generating procedures are necessary for emergency dental care, use high evacuation suction and dental dams to minimize droplet spatter and aerosols. The use of personal protective equipment including gowns, N95 respirators, goggles, face shields, etc. is recommended. During extended procedures with aerosols or splashes of water, saliva, or other bodily fluids that could cause moisture to collect on a filtering facepiece respirator, the use of R95, P95 or better filtering facepiece are recommended, including elastomeric respirators with an appropriate cartridge or powered air-purifying respirator (PAPR). Routine cleaning and disinfection procedures with an EPA-registered hospital-grade disinfectant for appropriate contact times is recommended and following CDC Guidelines for disinfection and sterilization in healthcare facilities and infection control guidelines (*e.g.* cleaning and disinfecting techniques from bloodborne pathogen practices including protecting vacuum lines with liquid disinfectant traps and high-efficiency particulate air (HEPA) filters or an equivalent.  **Dental unit water line and equipment maintenance after water stagnation period:** Dental practices should follow CDC guidelines for reopening buildings after prolonged shutdown or reduced operation 36. After a period of non-use, dental unit waterlines should be tested to ensure they comply with EPA (<500 CFU/mL) prior to expanding dental care practices. Practitioners are advised to consult manufacturers for need to shock the dental unit water line or any devices and products that deliver water used for dental procedures. Standard maintenance and monitoring of dental unit water lines according to instructions for use of the dental operatory unit and the treatment products. Autoclaves and instruments should be routinely cleaned and maintained according to manufacturers’ instructions. Sterilizers should be tested using a biological indicator with a matching control (*i.e.* biological indicator and control from the same lot number) after a period of non-use prior to reopening per the manufacturer’s instructions. Protocols for storage and maintenance from the manufacturer should be followed for storage of air compressors, vacuum and suction lines, radiography equipment, high-tech equipment, amalgam separators, and other dental equipment. | 36–44\* |

\*Dental guidance related to water included in this list; extensive guidance documents related to general COVID-19 infection control summarized by 45

**Table S2.** Cases of infection or illness reported from dental office water (SG= serogroup; Type = monoclonal antibody typing strain identified; ST = sequence type; NP = not performed)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Location of case or Outbreak (date of incident)** | **Pathogen** | **No. ill** | **No. died** | **Clinical/ env. isolate matching?** | **Likely source / Comments** | **Reference** |
| US | *L. pneumophila* and *L. longbeachae* | 1 | 1 | NP | -DUWL aerosols (not conclusive: clinical sample contained *L. dumoffii*, *L. pneumophila*, *and L. longbeachae.* These species were also found in the DUWL) | 14 |
| South Africa | NS | 1 | 0 | NP | -Thermal measures used to eliminate *Legionella*  -4/13 sites were positive for *Legionella* spp. initially, reduced to 2/13 after heat shock treatment  -Water supply temperatures were within ideal growth range  -Contributing factors included a faulty temperature thermostat on the hot water boiler, a faulty temperature gauge to the boiler, faulty non-return values, faulty hot water return pumps for boiler and cold water supply lines in roof space lacked insulation lagging | 43 |
| Italy (2011) | *L. pneumophila* SG 1 Type Benidorm ST 593 | 1 | 1 | Yes (See Table 1) | -High speed turbine instrument | 12 |
| US (2015) | *M. abscessus* | 20 confirmed, 9 probable | 0 | Not performed | -Attack rate 1%  -Median age 7 years (3-11)  -Median incubation period 65 days (18-164)  -All patients severely ill requiring hospitalization at least once for median 7 days (1-17 days)  -17 patients required surgical excision, 10 intravenous antibiotics  -All dental stations >500 CFU/mL HPC, *M. abcessus* found in all water samples; PFGE indicates common source | 75 |
| US (2015) | *M. abcessus* | 24 (14 confirmed) | 0 | Not performed | -Odontogenic infections in children after pulpotomy-cervical lyphadenitis, mandibular or maxillary osteomyelitis, pulmonary module  -Each child had >1 hospitalization and median of 2 surgeries (1-6), 11 received intravenous antibiotics, 19/24 experienced additional complications  -*M. abscessus* 91,333 CFU/mL in dental chair water; PFGE indicates common source | 76 |
| Sweden (2012) | *L. pneumophila* SG 1 Type Knoxville ST9 | 1 | 1 | Yes (See Table 1) | -Cupfiller outlet | 13 |
| US (2016) (Pediatric dental clinic) | Nontuberculous mycobacteria (NTM) | 71 cases (22 confirmed, 49 probable, 7 suspected) of 1,089 exposed as of March 19, 2018 | 0 | NP | -70 of 71 cases required surgical debridement as a result of infection.  -Permanent teeth lost in 45/65 who lost teeth.  -32 required intravenous antibiotics | 77 |
| US (2014) | *Enterococcus faecalis* endocarditis | 15 confirmed | 1 | NP | -Infections were among patients who underwent oral surgery  -12 of the 15 patients required cardiac surgery as a result of their infections  -Lapses in water-associated infection prevention practices: tap water instead of recommended sterile water used for irrigation during oral surgery procedures, hand hygiene not routinely performed | 78 |
| Venezuela (2020) | NTM | 3 | 0 | Yes | -Dental unit water lines determined to be origin  -Infection with *M. fortuitum, M. abscessus, M. peregrinum* | 79 |

**Table S3.** Exposure studies (biomarker studies) for *Legionella* spp. in dental settings (SG= serogroup; Type = monoclonal antibody typing strain identified; ST = sequence type; NP = not performed; NA= Not available) modified and updated from Petti and Vitali 2017.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Location of Study (date)** | ***Legionella* spp. antigen strains** | **Dental exposure population** | **Occupationally unexposed individuals** | **Seropositives (dental healthcare workers) positive/total (%)** | **Seropositives (unexposed individuals) positive/total (%)** | **Prevalence ratio (95% CI) (computed by Petti and Vitali 2017 unless noted)** | **Comments** | **Reference** |
| US | *L. pneumophila*  *L. micdadei*  *L. bozemanii* | Dentists, clinical-level students, assistants | General population | 54/270 (20) | 7/67 (10.4) | 1.91 (0.91-4.01) | -Exposure population divided into those with over 2 years of clinic exposure and those with 1 year or less | 80 |
| UK (1987) | *L. pneumophila*  SG 1,5 | Dentists, clinical-level students | Last-year medical students, young doctors | 9/152 (5.9) | 1/70 (1.4) | 4.15 (0.54-32.08) | -Cases of legionellosis were unable to be attributed to the dental institute  -Antibody prevalence in the exposed dental group was marginally greater than to those unexposed but for the immunofluorescence antibodies this difference may have occurred by chance  -multiple explanations are proposed as to why transmission of legionella was not found (i.e. low level of contamination, patient’s age, etc.)  -An environmental investigation was performed (see Table 1) | 51 |
| Austria (1988) | *L. pneumophila* SG1, 4, 5, 6  (detected) | Dentists, assistants, technicians | White-collar workers, non-dental students | 36/107 (33.6) | 5/106 (4.7) | 7.13 (2.91-17.47) | -No significant differences were found with regard to sex or age  -The proportion of dentists to assistants to technicians is not equal  - Prevalence was highest in dentists (50%), followed by dental assistants (38%), and dental technicians (20%) | 48 |
| Germany |  | Dentists, assistants | General population | 15/218 (6.9) | 16/293 (5.5) | 1.26 (0.64-2.49) | -Seroprevalence investigated in 113 dentists, 105 dental nurses and 17 dental technicians  -Substantial differences in prevalence of antibodies in different facilities  -Incidence of positive antibody titer increased with duration of occupation  -No history of pneumonia in dentists with high antibody titers  -An environmental investigation was performed in 12 dental offices (See Table 1) | 69 |
| London, Northern Ireland | *L. pneumonphila* SG1-6,8 | Dentists | Blood donors | 1/246 (0.4) | 12/500 (2.4) | 0.17 (0.02-1.29) | -No dentists reported experiencing Legionnaires’ disease or Pontiac fever; one dentist was diagnosed with a pneumonia of unknown cause  -One dentist had antibiotics to SG1 and one to SG3  -For 4 sites with *L. pneumophila* positive surgery plumbing, 3 dentists had negative serology and a fourth refused testing  -Prevalence of *L. pneumophila* antibodies in dentist group did not exceed control group  -An environmental investigation was performed (see Table 1) | 53 |
| US | *L. pneumophila* SG1-6 | Dentists | Clinically unexposed volunteers | 93/1076 (8.6) | 2/22 (9.1) | 0.95 (0.25-3.61) | -—Serum was collected from dentist volunteers and non-dentist voluneers attending the 2003 Health Screening Program of the American Dental Association  -Seropositive dentists provided a water sample from their dental unit and home shower (water samples tested for SG 1-14) and cultured for *Legionella* spp. None of water samples were positive and exposure could not be linked to dental unit or home shower water.  -Enzyme immunoassay (EIA) used  -Seropositivity of dentists and non-dentists was similar | 81 |
| Italy | *Legionella* spp. | Dental assistants exposed to dental environments | Dental assistants not exposed to dental environments | NA/44 (NA) | NA/44 (NA) | 3.5 | -Antibody levels > 1:128 were considered positive for infection | 47 |
| Italy- Turin (2008) | *L. pneumophila*  *SG 1-14* | Dentists, clinical-level students | White-collar workers | 32/119 (26.9) | 23/70 (32.9) | 0.82 (0.52-1.28) | -No association was found between the presence of antibodies and the presence of risk factors for legionellosis, pneumonia, or flu-like symptoms  -In Turin there was no difference to be found between dental office staff and office staff. | 45 |
| Italy-Bari (2008) | *L. pneumophila*  *SG 1-14* | Dental healthcare workers | White-collar workers | 14/44 (31.8) | 4/44 (9.1) | 3.50 (1.25-9.80) | -Bari dental staff were significantly more likely to be positive for *Legionella* antibodies (daily disinfection practices were a possible explanation for this difference) | 45 |
| US (2002-2012) | *L. pneumophila* SG 1-6 | ADA HSP participants who practiced dentistry | ADA HSP participants who did not currently or formerly practice dentistry | 509/4,877 (10.4)  Increased from 10.4 to 11% excluding those who had practiced in last 10 years | 34/326 (10.4) | 1.00 (0.69-1.44) (Estrich et al. 2017) | -Serum samples obtained from participants in the American Dental Association Health Screening Program (HSP) 2002-2012 excluding 2008-2011 (5,431 participants; 4,877 dental practitioners)  -Dental practitioners always or sometimes: wore a mask while treating patients (85%), face shield (40.4%), or N95 mask (19.5%)  -Inclusion criteria included participants with nonequivocal antibody test results, those who completed an HSP at the time of the test, were not immune-compromised and had a valid US zip code.  -Prevalence was 10.4% in both exposed and non-exposed groups but varied by region  -Authors concluded dental care did not increase risk of being exposed to *Legionella* | 82 |
| Bulgaria (2015) | *L. pneumophila* SG 1-6 | Healthcare (medical/dental; age 25, at least one year of service at a health facility, working with medical/dental water aerosol generating devices, no pneumonia within last 6 months) | Non-healthcare (over age 20, no pneumonia or dental work within 6 months prior to survey) | 27/66 (40.91) | 7/90 (7.78) | 8.21 (Kevorkvan et al. 2017) | -No association of seropositivity with sex, chronic disease, immune medications, smoking, or history of pneumonia  -There was a positive association for dental personnel; associated factors were age, use of personal protective equipment and workplace i.e. building with *L. pneumophila* present in water system  -One dentist found to have an antibody index indicative of an ongoing infection | 46 |

**Table S4.** Concentrations of *Legionella* spp. in dental unit waterlines and drinking water in dental offices

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Location (sampling date)** | ***Legionella* species and/or subtype** | **Method** | **No. samples (No. positive)** | **Concentration range in dental water (No. / L)** | **Comments** | **Reference** |
| Austria (1986) | *L. pneumophila* SG1 | Culture | 42 (4) dental units | >10^8 | -Article not available in English | 1 |
| UK (1985) | *L. pneumophila* | Culture | 5 dental stations (3)  8 inlet water (4)  16 high-speed drills (7)  8 ‘3 in 1’ syringes (4)  8 ultrasound descalers (1) | NS  102 - 103  103 – 105  103 – 105  103 | -Each dental station had 2 water-cooled high-speed drills, a ‘3 in 1’ syringe, water or spray for suction, a water outlet for an ultrasound descaling machine.  -5 pilot samples taken from high-pressure outlets of each station  -8 subsequent samples taken were separate from original 5 locations sampled  -First draw samples | 2 |
| UK | *L. pneumophila* SG8  *L. pneumophila* SG 10  *L. bozemanii* SG2  *Legionella* spp. | Culture | 6(4) (pre-chlorination DUWL)  NS (post-chlorination DUWL)  4(4) Air turbine handpieces and 3-way syringe  9 (1) High pressure tank after installation of charcoal filter | 104-4×104  104-105  104-105  104-106  104 | -Investigation was prompted by complaints of foul water at dental units  -Chlorination and charcoal filtration were not sufficient to reduce *Legionella* spp. concentration  -Water entering building was softened  -Chair-side installation of charcoal filters reduced legionellae for 7 days at which time it returned to levels >107 CFU/L; *L. pneumophila* SG10 was eliminated but *L. bozemanii* SG2 persisted. | 3 |
| Germany | *L. pneumophila* SG6  SG 3, 12, and 6 | Culture | NS (48) in warm water taps and dental units combined | 2×102- 4×103 (dental units)  5×102- 8×104 (hot water outlets) | -Warm water outlets in a surgery bacteriological unit taps and faucets and dental units were sampled  -Warm water temperatures ranged from 30-50°C  -0.3- 0.5 L samples taken after 16 h stagnation or more | 4 |
| Germany | *Legionella* spp. | Culture | 12 (7) (dental hot water supplies)  12 (6) (dental units) | NS [full paper not in English] | -hot water systems and dental units from 12 dental offices | 5 |
| USA (1995) | *Legionella* spp.  *L. pneumophila*  *Legionella* spp. | PCR  PCR  PCR  Fluorescence antibody  Culture | 265 (180)  265 (21)  30 PCR positive (DUWL)  40 PCR positive (potable water samples) | 36% <103  15% 103-105  14% 105-106  18% 106-107  17% >107  94% <103  3% 103-105  3% 105-106  0% 106-107  0% >107  45% <104  30% 104-106  15% 106-107  10% >107  35% <104  25% 104-106  24% 106-107  15% >107  75% <104  21% 104-106  5% 106-107  0% >107 | -265 total samples were taken from 28 dental facilities in 6 states. 126 potable water samples were taken for comparison (at non-dental fixtures), 50-100 mL samples  -Samples included water from high-speed drill handpiece lines, dental syringe lines, and scaler lines  -A subset of 30 samples examined by culture and epifluorescence microscopy showed concentrations in similar range as PCR data | 6 |
| NS | *L. pnuemophila* | Culture, IFA | 194 (44) air/water syringes  159 (26) high-speed outlets | 150 samples <1/plate  9 samples 1-10/plate  28 samples 11-100/plate  7 samples 101-1000/plate  133 samples <1/plate  9 samples 1-10/plate  12 samples 11-100/plate  5 samples 101-1000/plate | -194 dental units sampled from restorative dentistry, pediatric dentistry, primary treatment, and oral surgery units  -Units examined 3-6 times over a 44- month period, with 6-12 months between each sampling  -Samples were taken from handpiece outlet without handpiece attached, and from air/water syringes after 30s flush  -100 mL sample filter and filter divided between culture plates  -Of 49 positive units, 23 were positive on more than one occasion  -Of 91 units tested, 21 were positive for non-*pneumophila Legionella* species  -Certain equipment models of the same end-use were more prone to contamination than others | 7 |
| US | *Legionella* spp.  *L. pneumophila* SG1-6  *L. bozemanii, L. micdadei, L. dumoffii, L. jordanis, L. gormanii,* and/or *L. longbeachae* SG1-2 | Culture  PCR  DFA  DFA | 47 (31)  47 (29)  47 (1)  47 (19) | 2.7×108 (mean), 1.1×106-5.3×109 (range)  Mean ultrasonic scaler 4.2×108  20 samples ≤105  9 samples > 105  NA  NA | -*Legionella* spp. detected in samples analyzed by PCR (62%), DFA (40%), and culture (9%) | 8 |
| Italy | *L. pneumophila*  *L. bozemanii*  *L. dumoffii* | Culture, serotyping | 21 cup water (2)  21 air-water syringe (4)  16 Ultrasonic scaler (4)  Turbine (3) | Up to 6.75×103  Up to 1.68×104  Up to 1.95×103  Up to 8.85×103  900  4.2×103  300 (incoming water) | -101 total samples taken, 23 from incoming water lines and remaining from dental unit water lines  -Other opportunistic pathogens detected including *Pseudomonas* spp., *Stenotrophomonas maltophilia*, and *Burkholderia cepacia* | 9 |
| London, Northern Ireland | *L. pneumophila* SG14  *L. pneumophila* SG1  *Legionella* spp. |  | 166 (London- 1)  100 (Northern Ireland-0)  166(London-1)  166 (London- 3)  100 (Northern Ireland-0) | Surgery basin tap: 8×102  DUWL: 1.08×105  Surgery basin tap: 5.2×102  Surgery basin tap | -9.2% of water samples were collected in the spring, 15.8% in the summer, 36.9%  in the autumn and 38.1% during the winter months  -3 practices positive for *Legionella* spp. had positive isolates from hot water plumbing. All three practices had sinks fitted with mixer taps and crossover between the hot and cold supply may have occurred within the mixer tap. | 10 |
| European Countries (2004) | *Legionella spp.*    *L. pneumophila* SG1 | Culture, BCYE or GVPC agar | 237 (10) in dental unit water line  237 (3) in dental unit water line | NA | -Prevalence of opportunistic pathogens were assessed in dental unit water systems in the UK, Ireland, Greece, Spain, Germany, Denmark, and the Netherlands  -51% of dental unit water lines exceeded American Dental Association recommendations of ≤200 CFU/mL, *L. pneumophila* and *Mycobacterium* spp. recovered occasionally | 11 |
| Canada (NS) | *Legionella* spp. | Culture  qPCR | NS  12 (11) | Non-detect  Purge: Up to ~2.9×105  After purge: Up to ~7.2×104  After dental treatments: Up to ~6.0×104 | -Water samples taken from air/water syringes with a 2 mL/s flow rate  -Highest bacterial levels obtained in purge water  -Once per day, a 2-minute water purge was conducted | 12 |
| Italy (2002-4) | *Legionella* spp.  *L. pneumophila* | Culture with latex agglutination test and confirmatory PCR | 160 (19)  160 (0) | 36% < 2×105  25% > 2×105- 106  39% ≥ 106  No *L. pneumophila* quantified | -208 water samples collected; 160 from water supply of 4 dental chairs, 48 samples from cold incoming tap water of 2 units; 4 aliquots taken from scaler, air/water syringe, micromotor, and turbine  -*P. aeruginosa* also detected in 86 samples  -*L. pneumophila* found in potable water samples only | 13 |
| Italy | *Legionella* spp. | Culture | 87 (29) | NP | -102 dental units including 87 university and 15 public district facilities at 64 dental clinics in 8 Italian cities were analyzed  -Water samples from cup fillers and/or air-water syringes at start and end of morning practice  -One same was positive for both *Legionella* spp. and *P. aeruginosa* | 14 |
| Italy (2010) | *Legionella spp.* | Culture on GVPC agar medium | 60 (31) tap water before and during clinical practice  60 (30) DUWL before and during clinical practice | 0-7800 (from median values table 1)  0-12000 (from median values table 2) | -Microbiological investigation carried on in six dental clinics  -*P. aeruginosa* found in 33% of DUWS and *Legionella* spp. in 50% | 15 |
| South Africa | *L. pneumophila* SG1  SG2-14 | Culture | 13 (4) before heat treatment  14 (2) after treatment | Kitchen hot tap 103  Oral hygiene area (SG1)  1.2 ×103 (SG1)  Dental practitioner hot tap 200 (SG1)  Accounts kitchen hot tap 1.8 ×104, 8.8×103 (SG 2-14)  Dental practitioner cold tap 400 (SG1) | -An infection was reported in a dental receptionist (see Table 1)  -Thermal control measures were implemented | 16 |
| Germany (2009-2010) | *Legionella* spp.  *L. pneumophila* SG1 Type Oxford/Olda ST1 and Bellingham ST 847 | Culture, follow on monoclonal antibody and sequence-based typing tests | 71 (39)  71 (24) | Up to >1.25×107  <2×103 - 1.4 ×105 | -71 samples taken from 26 dental chair units with integrated disinfection devices and 31 samples from 15 plumbing sampling locations within the clinic building | 17 |
| Italy (2012) | *Legionella spp.* | Culture on GVPC agar medium | 20 (4) tap water before clinical practice  20 (4) tap water after clinical practice  15 (3) dental unit water before clinical practice  15 (3) dental unit water after clinical practice | 0-3700 CFU/L  0-5300 CFU/L  0-2200 CFU/L  0-3100 CFU/L | -Water contamination decreased during dental activities  -Decrease in air contamination occurred at end of day  -Surface contamination increased at end of activity | 18 |
| Italy (2012) | *Legionella spp.* |  | 297 (89) tap water samples before and after clinical practice  297 (47) DUWL samples before and after clinical practice | 0-8900 CFU/L (from min and max Table 1)  0-800 CFU/L (from min and max Table 2) | -*Legionella* spp. was  found in 29.96% (89/297) of tap water samples and 15.82% (47/297) of DUWS samples, with no significant  difference between pre- and post-clinical activity.  -Microbial air contamination was highest during dental treatments, and decreased significantly at the end of the working activity  -The microbial buildup on surfaces increased significantly during the working hours. | 19 |
| Italy (2011) | *L. pneumophila* SG 1 Type Benidorm ST 593 | Culture | 1(1) Dental cold water tap  1(1) dental unit waterline  1(1) high-speed turbine of dental unit waterline | 1.5×103  4×103  6.2×104 | -Dental unit waterline was disinfected with 12% hydrogen peroxide and shock chlorination; *L. pneumophila* reduced to <100 CFU/ L  -High speed turbine instrument identified as most likely source of infection | 20 |
| Germany (2009-2011) | *Legionella* spp.  *L. pneumophila* SG1  *L. pneumophila* SG 2-14  *Legionella* spp. non-*pneumophila* | Culture, serotyping | 90 (25)  25 positive (7)  25 positive (1)  25 positive (18) | 4 samples 10-990  13 samples 103-9.99×103  7 samples 103-9.99×104  1 sample >105 | -Samples from 56 dental units in 22 dental practices; 2 samples analyzed from 34 units and one sample from 22 units  -15/36 samples collected from an instrument channel and 10/54 samples collected from a cup filler were contaminated by *Legionella* spp. | 21 |
| Italy (2015) | *L. pneumophila* | Culture on GVPC selective Agar | 9 (2) tap water  11 (2) dental unit, no disinfection treatment  37 (5) dental unit, periodic disinfection (Rely + On Peracilyse)  11 (7) dental unit, continuous disinfection (ICX)  4 (2) dental unit, continuous disinfection (Calbenium) | 450-1250 CFU/L  200-300 CFU/L  350-3050 CFU/L  50-9000 CFU/L  250-9000 CFU/L | -Water delivered from syringes and turbines of 63 dental units were monitored for HPC, *P. aeruginosa*, and *Legionella* spp.  -Continuous disinfection did not prevent contamination by *Legionella* and *P. aeruginosa*  -Legionella was isolated from 36.4%, 24.3% and 53.3% of samples from  untreated, periodically and continuously treated waterlines, respectively  -Standard microbial indicators were not good predictors of *Legionella*  -Adoption of control measures including use of deionized water in dental unit waterlines and periodic/continuous disinfection controlled *Legionella* | 22 |
| Italy (2015) | *Legionella* spp. | Culture  PMA-qPCR | 60 (4)  60 (60) | 1×102-1.2×103  102-106 | -86 samples were collected from 26 private dental offices (60 from dental unit water lines and 26 from tap water)  -*Non-pneumophila* species only were isolated from the dental unit water lines | 23 |
| Slovenia (2016) | *Legionella spp.* | Standard ISO 11731 | 537 (98) DUWS | 80 of the 98 positive samples were <1000 CFU/100ml | -Kinney methods were used to evaluate risk based on probability of occurrence, frequency of exposure, and seriousness of the consequences (R=P\*F\*S); level of risk ranged from 30-45 by this metric *i.e.* “low risk”  -*L. pneumophila* SG1 represented 36.3% of all isolated *Legionella* spp. | 24 |
| Sweden (2012) | *Legionella* spp. non-*pneumophila*  *L. pneumophila* SG 1 Type Knoxville ST9 | Culture | 39 (6)  Cupfiller outlet of dental unit | -<100  -2×103 | -Showers with filters and taps sampled; showers with point of use filters were negative distal to filters but positive proximal to filters; samples proximal to filters contained 1000-2000 CFU/L.  -A clinical/environmental match was found between the patient isolate and dental unit cupfiller outlet  -Water purification with ichloroisocyanurate was applied to treat water used for instruments where aerosol formation risk was high but was not applied to the cup filler outlet | 25 |
| Italy (NS) | *Legionella* spp.; unspecified subset of strains identified as *L. pneumophila* SG1 and *L. pneumophila* SG2-15 in tap water and SG2-15 in DUWL | Culture | 48 (0) PDC tap water  104 (30) HOC tap water  13 (4) HOC DUWL  4(3) inlets  4(2) spittoons  4(4) handpieces  6 (2) PDC DUWL (LPSG2-15)  2(2) spittoons  2(2) handpieces | 104.91±0.69 (GM)  104.38±0.72 (GM)  103.99±0.61 (GM)  103.54±0.21 (GM)  104.30±0.17 (GM)  104.59±0.07 (GM)  104.15±0.13 (GM)  104.06±0.09 (GM)  104.24±0.12 (GM) | -Study performed at a hospital odontostomatology clinic (HOC) (13 dental units) and three private dental clinics (PDC) (6 dental units)  -Positive *L. pneumophila* detections in handpieces were often associated with *P. aeruginosa* (13/19 samples)  -Shock disinfection with 3% v/v hydrogen peroxide had a limited effect with recolonization after 4 weeks; *Legionella* only eradicated after 6% v/v shock disinfection and installation of filters, *P. aeruginosa* required additional treatment | 26 |