Chapter

Infection Control in Dentistry and Drug-Resistant Infectious Agents: A Burning Issue. Part 2

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Abstract

We showed that antibiotic-resistant bacterial infections inside of dental settings are relevant. Here, we have focused on the limited awareness on infection prevention guidelines, and the lapses and errors during infection prevention, which sustain the evidence of possible reservoirs of antibiotic-resistant bacterial infections in humans (dental staff and patients) and on dental items or in the environment. We chose Staphylococci and Enterobacteriaceae as markers since they are considered as prioritized bacteria according to antibiotic resistance pressure, and the data are available on their virulence factors and for dental settings. For better dental patient and healthcare personnel safety, we need to improve knowledge on bioburden and biofouling, based also on molecular biological methods, and education and training initiatives to limit the hazards in surgical dental settings and to sustain accreditation survey.

Keywords: dentistry, surgery, guidelines, infection control, MRSA, biofilm

1. Introduction

Antibiotic-resistant bacterial infections inside of dental settings are relevant and nearby [1] (Part 1). The limited awareness on infection prevention guidelines, lapses, and errors during infection prevention according to Centers for Disease Control and Prevention (CDC) dental guidelines sustains the evidence of possible reservoirs of antibiotic-resistant infectious agents (ARIAs) in humans (patients and dental staff) and in the environment (clinical contact surfaces (CCSs), dental instruments, and dental unit water lines (DUWLs)) and possible hazards mainly in surgical dental settings [2–26]. Here, we have focused mainly on hand hygiene, PPE use, environment decontamination, and instrument reconditioning [19, 20, 27–29]. We focus on Staphylococci and Enterobacteriaceae as markers since they are considered as prioritized bacteria according to antibiotic resistance pressure [30], and better knowledge is available on their virulence factors (adherence to abiotic surfaces, biofilm formation, ability to growth also in anaerobic conditions) and for dental settings (i.e., contamination of hands and environments, etc.). These features are important in the exploration of standard precaution failures since bacterial adherence to inanimate objects (i.e., many objects in dental settings, dental implants, collagen-based biomaterials, etc.) is known to be linked with the presence of surface components with nonpolar/hydrophobic vs. polar/hydrophilic characteristics; in particular for methicillin-resistant *Staphylococcus aureus* (MRSA), its estimated infective dose is very low (4 CFU) [31–42]. Fast and very sensitive molecular biological techniques (quantitative real-time polymerase chain reaction (PCR), multiplex PCR, microarray, next-generation sequencing technologies, etc.) and *in vivo* biosensors technology seem to be a very promising support to improve the knowledge on bioburden and biofouling, even due to not cultivable infectious agents by classical microbiological methods, and to monitor the effectiveness of item reprocessing [43–47].

2. Approach

The electronic literature search was conducted via the PubMed and Google Scholar databases (from January 2010 up to and including April 2018) using various combinations of the following key indexing terms: (a) patient safety, (b) infection control, (c) implant, (d) endodontia, (e) sterilization, (f) reconditioning, (g) critical items, (h) semicritical items, (i) hand hygiene, (j) DUWL, (k) sharps safety, (l) personal protective equipment (PPE), (m) disinfection, (n) MRSA, (o) VRE, (p) ARIAs, (q) guidelines, and (r) cross infection. In addition, manual searches were carried out in InTech books. Then, bibliographic material from the papers has been used in order to find other or older appropriate sources. A total of 125 papers and links were found suitable for inclusion in this chapter (Part 2). Only few papers do not have a DOI or PubMed classification, but the available links by Internet and accessed date have been added.

3. Infection control implementation: a closer look on patient needs and cost/benefit advantages

Marketing and financial strategies are emerging in dentistry. Concerning both, the improvement of infection control (IC) seems to be very important when taking into account dental patient needs and the first economic evaluations. A clean and hygienic appearance of the dental office, the sterilization of the instruments, the hand hygiene, and use of PPE of dental workers are essential requirements for patients, increasingly informed about cross infection in dental settings [48–52].

The first economic evaluations have been published concerning IC implementation [53]. The implementation of IC procedures for 1 year resulted in an infection reduction of 65% at a dental clinic [54]. Chen's group reported that the simple implementation of hand hygiene resulted in a substantial advantage in the cost/benefit ratio ($ 1 invested vs. $ 23.7 saved) for the hospital [55]. The total expenses for the investigation and response, related to the first case of patient to patient transmission for HCV infection in dentistry, totaled at $ 681,859.01. For every HCV infection that can be avoided with infection prevention, the estimated savings are of $ 30,000–$ 40,000 based on treatment costs for HCV infection using antiviral drug [56].

4. Noncompliance, lapses, and errors during infection prevention according to CDC dental guidelines

Manjunath recently focused on the management of MRSA patients in the dental chair [57]. MRSA can be transmitted by a carrier state, often asymptomatic, in dental patients and dental healthcare personnel (DHCP) (by contaminated hands) or by spray and splash, contaminated items. The spread of ARIAs can be restricted following standard preventions: hand hygiene, clinical contact surface disinfection, and instrument reprocessing are particularly important [16–20, 27–29]. In addition, we must limit the contamination by using premouthwash and surgical aspirators during clinical activity.

The insufficient compliance of guidelines during infection prevention in dentistry depends on the limited awareness of the infective risk and mainly the fact that the dentist will not share the same fate of the patient in the case of an adverse event (AE), but the financial-occupational consequences can be just as serious as that of an airplane crash [5–8, 56, 58, 59]. Here, we confirm the current significant extent of violations and main noncompliance in IC observed in dental settings (**Table 1**), sadly not different from those previously reported [12–15, 60–68].

4.1 Hand and glove contamination of DHCP

In 1991, MRSA transmission was caused by ungloved hands of a dentist on two patients during dental surgery (see in [10]). Nowadays, this situation is likely to happen due to the violations or noncompliances of hand hygiene and the use of PPE (**Table 1**) as stated in the key recommendations for hand hygiene and for PPE in dental settings [3]. In addition, MRSA hand carriage rates in dental patients, nurses, and dentist were 9.8, 6.6, and 5% [21]. Staphylococci were detected in 57% samples from gloves *S. aureus* (5%), CNS (52%), *S. epidermidis* (44%), MRSA (1.5%), MRCNS (2.2%), MRS *epidermidis* (1.5%), respectively [69].

The rationale of surgical hand washing and the correct gloving is to preserve surgical glove sterility. Since the high turnover of dental patients in private practice and the need for frequent hand hygiene, alcohol-based (95% wt/wt) hand rub is recommended as a speeder alternative to surgical scrub (4–5 minutes) and to apply:

- when hands are not visibly soiled
- before donning gloves and after glove removal
- following instruction for use (IFU) (product amount, time) by the manufacturer since are efficacious on MRSA even when gloves were not used for routine clinical care [70]
- since DHCP needs short time procedures and it takes only 20–30″
- since it is safe for patients and workers [71].

Concerning gloves, the physical properties of different materials influence bacterial passage in case of glove puncture due to sharp injuries [27–29, 72]. Glove perforation was 17% in maxillofacial surgery, and occurred significantly more frequently in procedures that exceeded 90 minutes than in those taking less time or during surgical procedure with a high risk of percutaneous injury rate (long procedures: intermaxillary fixation, sinus lift), in surgeon and first assistants. In addition, endodontia and orthognathic surgery are at high risk of glove perforation [13, 73]. Needlestick and sharp injuries occur as a consequence of poor visibility, unexpected patient movements, and during the clearing up of dental instruments at the end of treatments and manual cleaning [27–29, 74]. According to the European Directive n° 32/2010 and National rules, there are a lot of key recommendations for sharps' safety and good practice guides for sharp safe dental treatment [3, 29]. Sharp injuries can be reduced to a degree by behavioral changes, training, and engineering

Study (publication date, country) [reference]	Dental setting	Hand hygiene (%)	Use of protective eyewear (%)	Use of gloves (%)	Wearing/ use of mask (%)	Instrument reprocessing (%)	Autoclave quality control (%)	Handpieces reprocessing after every patients (%)	Other violations or noncompliances (%)
Hübner et al. (Germany) [60]	35 dental practices	11	15–23			6 (autoclave class N)	80	67	
Mutters et al. (Germany) [61]	58 invasive dental cares in university dental clinic	95 (N) 61–65 (D) (after glove removal)		14.3 (D♀) 28.6 (N)	16 (N)				Presence of jewelry during DP in N (80.7%)
Copello et al. (review) (Italy) [62]	76 different dental practices (dentist males (78%), professionals aged 50 years or above (59%)		40 (goggles)			2 (lack of steam autoclave class B)			DUWL: 10%: lack of any infection control; 50%: absence of analytical control of the DUWL water was carried out only in nearly half of the dental practices; 77%: absence of a microbiological assessment of the work-environment contamination. 15% of the dental practices: presence of expired pharmaceuticals; 40%: not regular stocking of waste materials
Balcheva et al. (Bulgaria) [63]	94 dental students	35.5 (prewash); 8.5 (postwash)	79.8 (goggles); 95.7 (shield)	8.5	33.0 (use); 51.1 (mask change)				

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Anders et al. (USA) [64]	214 dental students (third-fourth year)	56.8 (during the preoperative phase); 23.3 (postoperative phase after removing gloves)		53.7	35.7				12%: overall noncompliance with infection control parameters in dental students
Dagher et al. (Lebanon) [65]	1150 private dental clinics	9.9	54.3	7.6	10.9	21 (automatic washing of used instruments); 35 (steam autoclave) ; 34.7 (dry heat sterilized burs and 39.7 (dry heat sterilized endodontic files; 29.6 (wrapping barrier for instrument sterilization)		72.3	19 (wiping with disinfectant on CCSs); 44.9 (use of surface barriers); 61.6% (impression disinfection
Mandourh et al. (Saudi Arabia) [66]	107 dentists working in 34 private dental clinics in ten districts (♂: 66.4%; ♀: 33.6%)	65.4 (after glove removal (D) with the daily workload (>10 patients/day): the correct time (66.3%); correct duration (41.3%) and drying (18.8%); after removing the gloves (25%); washing with soap and water after contact with saliva (56.3%) or alcohol hand rub when hand is visibly dirty (80%)	♂:8.5; ♀: 5.6 (nonawareness of wearing protective eyewear)	54.2	11.2	Keeping sterile instruments in pouches (3.8%)		4.6	70%: unsafe work behavior of bending needles after use; 12.2%: not disposing sharps in a safety container; 2.8%: do not believe separation of blood-soaked waste is important. The incorrect practice of opening drawers with contaminated gloved hands was done by 81.3% of the dentists with daily workloads of more than 10 patients.

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Yadav et al. (India) [67]	30 dental surgeons working in a private dental hospital	50 (hand sanitizer)	93.4	5 (disposable gloves) 80 (sterile gloves)	20	66 (autoclave); ~70 (use of irritant disinfectants for instruments; 10 (bur reconditioning); 30 (endodontic files reconditioning)	10		100% (use of rubber dam); 90% (use of high speed evacuator); 100% (use of surface barriers)
da Costa et al. (Brazil) [68]	641 undergraduate dentistry students, 20 Ph.D. students, 15 oral radiology professors								Many factors in oral radiology, mainly associated with: plastic barriers, performance of infection control procedures; use of overgloves

D, dentist; N, dental nurse; DP, dental procedure; , female; , male; CCSs, clinical contact surfaces.

Table 1.
Violations or noncompliances (%) concerning selected infection control procedures.

innovations. Nevertheless, with the exception of free-standing needle guards, needle burners, blade-safe surgical blade remover, and rigid puncture-proof yellow hidden waste bin, some engineering innovations (i.e., disposable retractable scalpel blade, blunt-tip suture needles) are no longer the methods of choice or it is not proven best protection in dentistry. There is no data on the best protection and early identification of perforation of using double gloving with an indicator in dentistry [75]. Single-use gloves intended for use in nonsterile areas must meet the requirements as reported and an AQL of ≤1.5 in accordance with EN 455–1 [76]. However, Al-Swuailem found gloves with higher defect rates (as high as 20%) than what is considered acceptable (2.5%) according to the international regulations [77]. Then, we suggest extreme caution on the cheapest gloves and at lower quality of sterile gloves available in the market, as these could have unclear or fake AQL, which is crucial for glove perforation. It is not known whether *Enterococcus* hand carriage is possible in DHCP for prolonged periods [78, 79], but the glove perforation is high in endodontics also using electronic root canal length measurement devices [80].

4.2 Environmental contamination in dental setting

Nowadays, it is widely recognized that environmental surface contamination plays an important role in the transmission of healthcare-associated infections [81]. The aerosols generated by high-speed handpieces, ultrasonic scalers, air polishing, air-water syringe sprays, contaminated water from DUWL [82], patient's saliva and blood, and respiratory secretions from MRSA carriers could cause air and then CCSs and item contamination, above all when dam and surgical high-speed evacuator are not used. *Staphylococcus* and *Enterococcus* species are present in DUWL water [83]. Despite the fact that DUWL biofilm is intrinsically resistant to antibiotics, Omogbai's paper showed a wide presence of ARIAs, mainly associated to *Pseudomonas* ssp. isolates [84].

We underline the numerous violations and noncompliance concerning two aspects: (a) the use of standard surgical masks, which is risky in relation to MRSA carriers among DHCP and (b) surface disinfection [1, 21, 65] (**Table 1**). Barenghi reviewed the microbial contamination of CCSs and analyzed the guidelines, products, and procedures (barrier protective coverings, disinfectants vs. cleaners, impregnated wipes, choice of surface disinfectant and wipes) for the management of CCSs [13–15]. Here, we report some updated data focused on ARIAs.

There was no indication of a special tendency or heightened ability of MRSA to aerosolize [85]. *S. aureus*, including MRSA, can remain virulent for 10 days on dry surfaces and survive for 7 days to 9 weeks on dry inanimate surfaces and 2 days on plastic laminate surfaces, while *Enterococcus* spp., including VRE, can survive from 5 days to 4 months on dry inanimate surfaces [86–88].

Since 2006, the dental operatory had to be considered a possible reservoir of MRSA [89]. Before the revision of IC protocols, 6% of patients were infected by HA-MRSA among those hospitalized for oral and maxillofacial diseases. After treating the patients under a revised IC protocols, including single use of barrier covers, MRSA was not detected on the surfaces of the dental operatory, and no HAI occurred during hospitalization. MRSA long-term persistence in a simulation of dental operative conditions up to 4 months suggests that the risk for MRSA diffusion on CCSs is high in the dental office [90]. In fact, hydrophobic microorganisms adhere relatively easily to medical devices and CCSs constructed from hydrophobic materials (rubber, silicon, stainless steel, teflon, etc.); in addition, the bacterial attachment depends on many other factors (material topography at the micro- and nanoscale) [40–42].

The dynamics of microbial colonization among patients, staff, and inanimate surfaces are not known in dental settings [91]. A dental operative room is certainly different from a hospital room, but the turnover of patients, relatives, and DHCP could be very high, especially in orthodontic offices. The presence of ARIAs on CCSs in dental setting has been confirmed from the puzzle of different operative theaters:

- 21% of dental students and 8.4% frequently touched dental school clinic surfaces were MRSA positive [92],

- 1.3% of the environmental isolates were MRSA-positive, and there were no statistical differences in biofilm-forming ability between MRSA isolates recovered from DHCP and those recovered from environmental surfaces [21],

- 10-fold increase in viable bacteria during periods of clinical activity vs. the absence of such activity, 73 species selected and 48% of species resistant to at least an antibiotic using 16S ribosomal RNA gene sequencing [93],

- greater contamination of surfaces with MRSA colonies was observed after patients were treated in five different departments of a hospital dental clinic. High prevalence of MRSA strains has been observed on various surfaces, especially the paper dental records in the oral medicine department [94],

- MRSA prevalence rate was different in samples from dental surgery (4.3%), prosthetic dentistry (3.9%), operative dentistry (2.9%), periodontics (2.4%), prosthodontic (1%), and endodontic (0.98%). The majority of MRSA and SA isolates recovered from environmental surfaces were biofilm producers [21, 95],

- the contamination of *S. aureus* and MRSA on the gloved-dominant hand and the tray are similar, being 5 and 1.5% respectively [69],

- the more frequently contaminated items were panoramic headrest/chin rest, radiation shields, towel dispenser, keyboard, and chair arm inside patient care areas of an academic dental clinic. 4.7% of abiotic surfaces in treatment and nontreatment areas were contaminated with *S. aureus* (<5 CFUs). Most isolates were resistant to penicillin [96],

- a high contamination of SA and MRSA species have been reported from materials used in radiographic processing, mainly on the lids of the portable dark rooms [97],

- in dental settings, the phone contamination is very high and is by *S. aureus*, *E. coli*, *Enterococcus*, and *Pseudomonas* (see Ref. in [13–15, 98]),

- only a few, dental surfaces were positive for *E. faecalis* (0.9%), but on the other hand, disinfection of surfaces reduced contamination levels by only 10% [54]. After clinical activity, the microbial surface contamination by *S. aureus* and *E. faecalis* was, 20 and 10%, respectively [93], and

- widespread microbial contamination of air, surface, and dental unit water samples and violations concerning environmental cleaning have been reported in dental surgeries [17, 18].

Recommendations for assessing the effectiveness of disinfection and cleaning practices indicate that the suitable levels of total bacterial numbers in the health care setting are in the range of 2.5–5 CFU/cm^2 [99]. It has been shown that the presence of a significant total coliform contamination, as markers of the presence of feces, before surface disinfection or on some dental materials "received from manufacturer" and/or "clinically exposed" (see in Ref. [13]). MRSA contamination has been detected on 2.8% of fomites [99]. Since, we frequently touch multiuse vials containing bonds, cements, pastes, etc. with contaminated gloved hands, it is important to remember that *S. aureus* and *E. faecium* may retain viability on plastic for longer than 1 year [100]. Avoiding touching everywhere with contaminated gloved hands (i.e., inside the drawers) or contaminated hands after glove disposal and obviously before a proper hand hygiene.

4.2.1 Resistant and susceptible strain survival to surface disinfectants

In general, there was no obvious difference in survival to biocides between multiresistant and susceptible strains of *S. aureus* and *Enterococcus* spp. [101]. Biocide resistance is rare since the biocides affect multiple cellular components, and this is more of a problem for Gram-negative bacteria (i.e., *Pseudomonas*), but not for *S. aureus* [102]. Resistance problems do not emerge when efficacious surface disinfectants are used properly following instruction for use (IFU) [103]. Two tested antibiotic-resistant microorganisms (MRSA, VRE) resisted to intermediate-level disinfectants in off-label conditions [104]. Recently, seven cleaning-disinfecting wipes and sprays, based on different active ingredients, were tested for their efficacy in removal of microbial burden and proteins in hospital settings. Efficacy was tested with known Dutch outbreak strains. In general, a > 5 log10 reduction of CFU for tested wipes and sprays was obtained for all tested bacteria strains, with the exception of the hydrogen peroxide spray and VRE [105].

Today, it is important to check the products carefully, including the specific biocidal activity (i.e., spectrum and time of action) at least of the main ARIAs, you use to avoid gray-market products (i.e., without approval in accordance with European Community (EC) product directives and/or FDA requirements, defective or expired) [11]. Nevertheless, inefficient surface decontamination (improper procedures, time below the contact time, insufficient dispersal, etc.) (**Table 1**) can then allow for the survival and growth of the surviving bacterial population [54, 93, 106]. The use of disposable barrier protective coverings (DBPCs) (transparent food barriers, purpose and medical-grade barriers, adhesive barriers) is recommended in particular for more contaminated zones of instruments (curing lights, intraoral radiographic equipment, computer keyboards, multiple-use dental dispenser devices, etc.), dental chair parts (dental suction units, light arms), buttons, switches, and other materials and accessories [13–15, 107]. In the future, it will be ergonomic to increase the use of the no-touch procedures (vaporization with hydrogen peroxide, HEPA filters, etc.) and rapid systems to control environmental cleanliness above all for surgical rooms.

4.3 Dental instrument reconditioning

Poor or bad instrument reconditioning practices for critical dental items are linked to cross infection [108]. Here, we reported the failures concerning dental instrument reconditioning, which includes decontamination, cleaning, wrapping, sterilization and storage. Since many multiresistant and susceptible bacterial strains in dental settings are good biofilm producers and then survive to desiccation, and are more resistant to disinfectants than planktonic communities, afterwards, the inadequate reconditioning of reusable dental instruments can potentially increase cross infection and outbreak [22, 109]. It is very important to avoid the drying of biological fluids on instruments and long delay in reprocessing (better within 6 hr) [110]. Main violations or noncompliances concerning all phases of instrument reconditioning in dental settings (**Table 1**) are very frequent and can be classified as follows: (a) lack of resources (es steam autoclave class B, unwrapped devices, insufficient drying, autoclave quality controls, etc.); (b) cleaning difficulties, above all for manual procedures, in the case of older, more complex instruments (implant drills, trephine drills, healing abutments, high-speed handpieces, torque wrenches) and dirty instruments with biological fluids, cements, bonding, adhesive, etc.; (c) many difficulties during reprocessing of surgical drills, endodontic instruments and their accessories; (d) use of water of uncertain quality for cleaning and steam autoclave; (e) insufficient training; (f) selection of item design with difficult clean ability; (g) loss of sterility; and (h) reuse of single-use medical devices (i.e., irrigation sets) [5, 12, 13, 23–26, 38, 111–115]. MRSA was demonstrated to survive on sterile item packaging for more than 38 weeks [113]. In general, the operative problems during surgical instrument reconditioning are more frequent since instruments can be single-end sharps (elevators), heavy (forceps), and joint fit (bone chisels, scissors, forceps, suturing forceps, etc.); in addition, they often have a hole and/or a cavity or are very little and sharp (drills, trephine drills). Instruments or surgical drills made with different alloys or old or very used are particularly tricky to recondition; we have to follow IFU to avoid corrosion and discharge them when have been damaged during clinical procedure (i.e., contact between bone drill and dental periosteal elevator) and/or reconditioning (i.e., lack of compatibility, contact in ultrasonic washer) [23–26]. Surgical and dental instruments should be discharged when corrosion stains, signs of milling or grazes [116], etc., are present. Since the reported contamination on surgical drills and instrument, we have to follow IFU and use ultrasonic washer with proper cleaning products using controls [117].

The use of surgical cassettes with modern hole patterns and washer disinfector allows an optimal cleaning and thermo-disinfection of surgical instruments with little occupational risk and better efficiency and instrument integrity. Surgical cassettes have different sizes, configurations, and can be specialized to meet specific surgical needs [118]. In the case of implantology, the surgical cassette normally holds some hand instruments, drills and screwdrivers, torque ratchet, and accessories for implantology. The correct sorting of the instruments is facilitated by the color-coding markings and pictograms [119, 120]. Manufacturer's electronic information for the processing with EN ISO 17664 is available.

Another advantage of this planning is that the surgical kit is reassembled directly in the operating room, and instruments are fixed in the open position. Using WD, there are advantages of no instrument contact or rubbing, and better automatic cleaning. Routine quality control is possible by inserting appropriate controls for cleaning efficacy (wash-checks WD STF, Browne) and the moist heat process (Des-check, Browne) inside the cassette. Recently, Valeriani proposed a fast simple molecular approach (by microflora DNA analysis) for monitoring the effectiveness of item reprocessing, which seems to be a very promising support for surveillance in dental care settings [46].

5. Conclusion

The prevention of cross infection by adopting guidelines is easily applicable and has had early significant effects on infection prevention and cost saving [53, 54] compared to the delayed significant effects due to the sustainable use of antibiotics in dentistry [121]. We reported many concurrent violations and noncompliances in infection prevention, some of which could not necessarily be harmful. Nevertheless, the infective risk is usually estimated in healthy people, while vulnerable patients (children, pregnant women, elderly people, diabetic, immune-deficient, under drug treatments, etc.) are particularly susceptible to infections from opportunistic pathogens and ARIAs. Elderly people are particularly exposed since they are often on antibiotics, situations, which favor antibiotic-resistant pathogens, and frequently require implant surgery and endodontic care. The hazard for our reputation and insurance coverage is increasing with the possibility offered by molecular biology to identify dentally acquired infections [1]. Molecular biology and *in vivo* biosensors technology, to detect quorum sensing signaling molecules produced by airborne pathogenic bacteria, can prove the violations and noncompliances in dental settings and useful for accreditation surveys [43–47, 58]. Nevertheless, antimicrobial surfaces and graphene-based antimicrobial nanomaterials seem to be promising to lower cross infection [122].

Concerning IC, we need to rapidly improve the efficacy and efficiency in IC prevention by means of:

- a better knowledge-based and rule-based behavior according to guidelines
- increased training and skill-based behavior
- high proactivity & interaction & communication among DHCP
- appropriated human and economic resources
- proper time for IC prevention (hand hygiene, gloves and mask use/change, etc.)
- use of surgical facemasks designed to rapidly inactivate dentistry-associated pathogens
- DUWL water quality and the use of sterile solution for surgery [6, 7, 14]
- digital models produced by an intraoral scan to eliminate the problem of impression and high contamination of gypsum casts (i.e., MRSA: 26.7, 15.4%, 27 respectively) [123, 124]
- more automation and no-touch procedures for cleaning and disinfection
- acceptable workload-occupational stress to avoid DHCP distraction
- use of proper items with FDA and/or CE mark [11].

For future safe and patient-centered dental cares, it is crucial that we increase the professional harmonization and ergonomics of the highly complex "human-technical dental office system" [125]. For better dental patient and DHCP safety, we need to improve education and training initiatives.

Conflict of interest

L.B. had a service agreement with KerrHawe and is a consultant for Dental Trey Il Blog (http://blog.dentaltrey.it/), neither of which gave any input or financial support to the writing of this article. There is no other conflict of interest to report.

Abbreviations

AE	adverse event
ARIA	antibiotic-resistant infectious agents
AQL	accepted quality assurance level
CDC	centers for disease control and prevention
CCSs	clinical contact surfaces
DD	dental device
DHCP	dental healthcare personnel
DI	dental implant
DUWL	dental unit water line
EC	european community
HPC	heterotrophic plate count
IC	infection control
IFU	instruction for use
MRSA	methicillin-resistant *Staphylococcus aureus*
PCR	polymerase chain reaction
VRE	vancomycin-resistant *Enterococcus*

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