

# Chemical hazard for dental hygienists: a systematic review

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**Abstract. – OBJECTIVE:** Dental hygienists (DHs) are professionals responsible for oral health. They deal with professional oral hygiene, counselling, and screening patients for oral health, as well as preventing and treating oral diseases. However, DH responsibilities and duties may vary worldwide, characterising changeable occupational exposure scenarios and making it difficult to achieve a suitable evaluation of workplace risks, particularly regarding chemical exposure. Therefore, the aim of the present work was to provide a comprehensive overview on the current knowledge on DH chemical risks.

**MATERIALS AND METHODS:** According to the PRISMA guidelines, a systematic review of PubMed, Scopus, and Isi Web of Knowledge databases was performed to retrieve all articles assessing DH occupational chemical exposures.

**RESULTS:** Fragmented data are currently available on DH chemical risk, due to the limited number of studies on the topic and few DHs enrolled, as well as their frequent assimilation to other oral healthcare professionals. The majority of the retrieved investigations focused on possible hypersensitivity reactions caused by natural rubber latex exposure, but not on potential risks derived from other currently employed substances or innovative wide-spreading compounds.

**CONCLUSIONS:** Future research should be focused on assessing DH chemical risks according to a more comprehensive and toxicologically standardised approach to achieve an appropriate awareness among the DH workforce concerning the possibility for hazardous exposure and adverse health effects. Overall, this may lead to the adoption/implementation of adequate preventive measures to protect the health and safety of these oral healthcare professionals.

## Key Words:

Dental hygienists, Oral healthcare professionals, Occupational chemical exposure, Natural rubber latex exposure, Workplace risk assessment, Occupational risk management.

## Introduction

Dental hygienists (DHs) are defined by the American Dental Hygienists Association (ADHA) as the oral health professionals responsible for preventing and treating some oral diseases<sup>1</sup>. It is a relatively recent profession, since the first US Fones School of Dental Hygiene opened in Bridgeport, Connecticut in 1913, and the first professional association, ADHA, was founded in America in 1923<sup>2</sup>. In Europe, the British Society of Dental Hygiene & Therapy was founded by a group of 12 dental hygienists in 1949 and nowadays it is a nationally recognized body throughout the United Kingdom<sup>3</sup>. In many other countries, however, this profession has been identified and regulated more recently: in Italy, for instance, the first School for Dental Hygienist was founded only in 1978<sup>4,5</sup>.

Together with the great variability in recognition date of this profession among different nations, also activities and possible procedures that DHs can perform considerably vary between countries worldwide. Depending on the law of the country in which they practice, these professionals may have variable responsibilities and duties that do not allow to univocally define the DH task. Professional oral hygiene is the core of the DH job activity, although other tasks can be

generally performed. These may include providing patients oral hygiene education/instructions and counselling them on good dietary strategies; screening patients including the evaluation of their oral health, collection of oral health history, screening for oral cancer, inspection of head and neck; applying preventative materials to the teeth; performing organizational activities such as documentation and office management. However, some State requirements may allow DHs to carry out duties including topical prophylaxis and preventive management of caries, periodontal disease, and tooth wear, x-rays, topical anesthesia, fluoride, and pit and fissure sealants under either direct or general supervision of a licensed dentist<sup>1,6-8</sup>.

Such great variety of potentially dangerous job activities and the consequent changeable occupational exposure scenarios make it difficult to comprehensively assess risks for DHs. Particularly, the DH chemical risk evaluation appears an even more challenging issue considering the multitude of substances they may be exposed to. These may range from disinfectants and acrylic resins, up to metals present in amalgams and natural substances, and the natural rubber latex (NRL) in gloves.

Unfortunately, to date, no comprehensive overview is available on chemical risk evaluation in such peculiar occupational setting. Therefore, the aim of this review was to systematically assess available studies on this topic as a means to gain deep insight into hazardous exposure situations for DHs both in ordinary conditions of work, as well as in case of accidental events, in order also to define knowledge gaps and future research needs. Overall, this may provide a valid support to define/improve suitable strategies for risk assessment and management aimed to protect the health and safety of DHs.

## Materials and Methods

This systematic review was performed following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)<sup>9</sup>. Inclusion criteria were: full papers, English literature published in peer-reviewed journals, observational studies assessing the chemical risk and focused on DHs. Exclusion criteria were: non-observational studies, case reports, systematic and narrative reviews, studies regarding occupational risks diverse from chem-

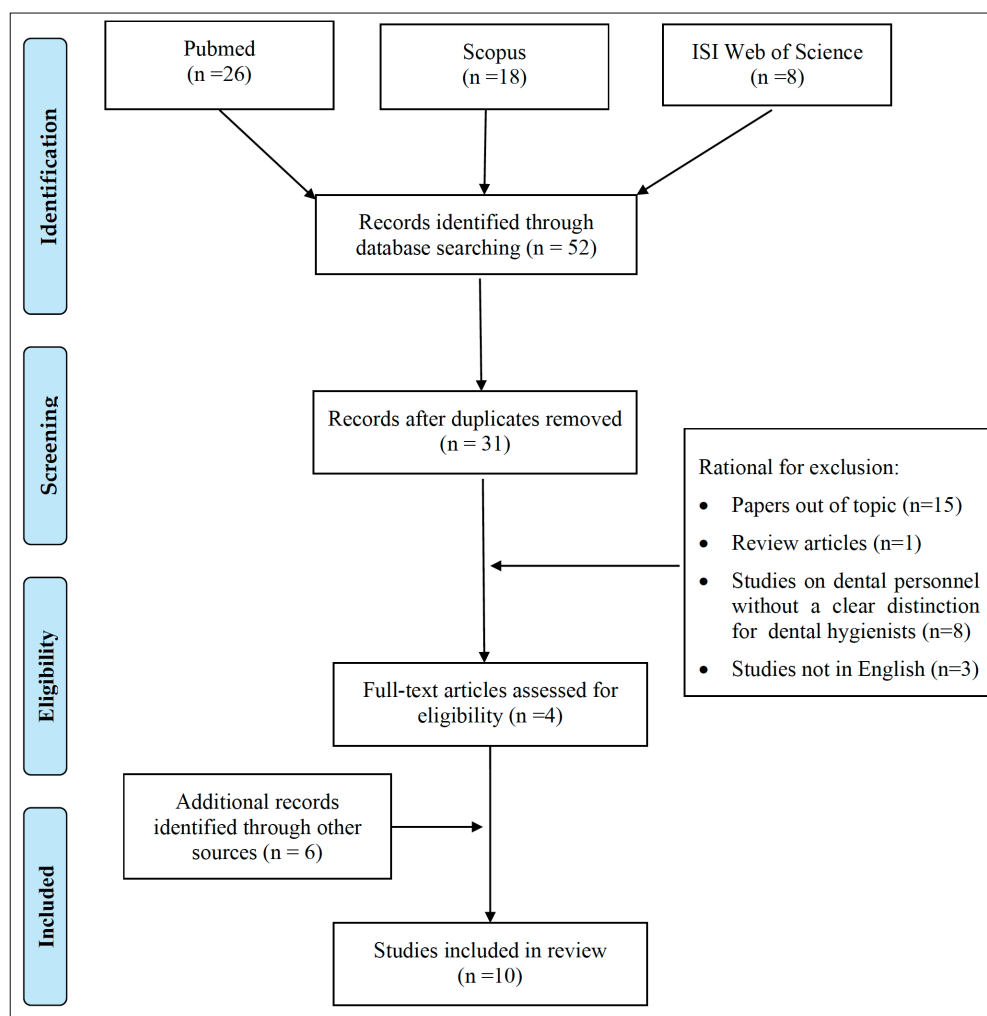
icals, studies in which it was not possible to distinguish among different oral professionals (i.e., DHs and chair assistants DHs, and dentists).

PubMed, Scopus, and ISI Web of Science were searched to identify all suitable studies published up to April 2019. The search was carried out first through the keywords “dental hygienist” to define the population surveyed, “occupat\*” to identify the context, and “chemical\*” or “chemical exposure” or “chemical risk” to define the hazardous factors of interest. The three search strings were combined by the Boolean operator “AND”. The preliminary search retrieved 26, 18, and 8 references through PubMed, Scopus, and ISI web of Science databases, respectively, for a total of 52 articles (Figure 1). After removing duplicates, 31 articles remained. The titles and abstracts of all these papers were independently screened by three authors (CL, GM, and VL). Among these papers, we excluded studies that did not meet the inclusion criteria according to the following reasons: studies published in languages other than English (n. 3); studies investigating dental personnel without a clear distinction for DHs (n. 8); studies out of the topic from title and abstract analysis (n. 15); review articles (n. 1). Indeed, 4 publications could be identified in this preliminary phase. Therefore, we extended our research, including the substance categories or the individual names of the substances as free terms, i.e., natural rubber latex, glutaraldehyde, formaldehyde, nitrous oxide, acrylates, fluoride, disinfectants, metals, mercury, and combining them with previously employed terms “dental hygienist” and “occupat\*”. Moreover, the assessment of the reference list accompanying published articles was employed to supplement the pool of relevant publications. This search allowed to include 6 additional studies. All full texts of the articles considered valuable for the aim of our review were obtained, and a critical evaluation was performed. Overall, our search retrieved a total of 10 publications for review. Finally, a qualitative synthesis of included studies was conducted, and the health outcomes were also analysed and summarised.

## Results

The following paragraphs will attempt to summarize information retrieved from available articles (Table I). Most of the studies addressed NRL exposure as a source of DH chemical risk, and

**Figure 1.** Flow diagram of literature search.



it was separately analysed from other chemicals (i.e., acrylic resins, formaldehyde, and mercury) as NRL is a naturally derived substance.

### **Natural Rubber Latex Exposure**

Natural rubber latex hypersensitivity reactions in 34 US oral health professionals, including 4 DHs with an average of 10.8 years of exposure to the substance was investigated by Safadi et al<sup>10</sup>. Among those 4 DHs, only one experienced hand dryness and redness after use of NRL gloves and tested positive at the NRL skin prick tests (SPTs). In a subsequent study, Hill et al<sup>11</sup> investigated 390 US dental professionals including 13 DHs (3% of the total oral professional sample) employed for a mean of 8.6 years, to assess the health effects of NRL exposure, acrylic monomers, and glutaraldehyde. Five DHs reported a positive history of hand dermatitis, although none had pathological reactions at the patch test. However, these data should be interpreted with caution due to the

small number of enrolled DHs. Hamann et al<sup>12</sup> conducted a study on NRL allergy, specifically focusing on a sample of DHs attending the 2000-2002 ADHA US national meetings. Out of 582 participants, 28 (4.8%) were positive for Type I allergy at the SPTs. Of these positive workers, 46% reported some type of symptoms after contact with NRL, most frequently respiratory problems and hives. In this study, the prevalence of allergy showed a decreasing trend over time, from 5.4% in 2000 to 3.4% in 2002. Consistent with this trend, prevalence of type I NRL hypersensitivity resulted lower compared to the results obtained by the same group of researchers in a previous research<sup>13</sup> carried out in 1994-1995 that reported positive SPT findings in ~9% of DHs and assistants. Interestingly in this latter study, DHs were more likely to have a positive hypersensitivity test compared to dentists (~5%). Considering the comparable time spent wearing gloves between both groups, it cannot be exclud-

Table 1. Summary of the studies analyzing possible chemical risks in DH occupational exposure settings.

Study setting	Study type	Period of investigation	Studied population	Pre-existing conditions	Task details	Outcome	Results	Reference
Cleveland Clinic Foundation, Ohio, USA	Cross-sectional	August-December 1994	Total OHPs: 34 (10M+24F); DHs: 4 (1M+3F; mean age 40 ± 9 y)	Hand dryness and redness after use of NRL gloves (n. 1 DH)	Mean NRL exposure: 10.8 y.	NRL hypersensitivity reactions (type I)	The only one DH that showed hand dryness and redness demonstrated positive NRL skin test	Safadi et al <sup>10</sup>
Air Force dental clinics, San Antonio, USA	Cross-sectional	March, April 1995	Total OHPs: 390 (257M+133F); DHs: 13. Mean age of enrolled subjects: 29 y	Hand dermatitis (n. 5 DHs)	Mean employment as OHP: 8.6 y reactions	Dental allergen hypersensitivity	No positive reactions were detected at the patch tests for i.e. NRL, nickel sulfate, methacrylates, glutaraldehyde in the 5 DHs positive for hand dermatitis	Hill et al <sup>11</sup>
ADA annual sections in New Orleans and Las Vegas, USA	Cross-sectional	October 1994 and October 1995	Dentists: 1372 (mean age 48.01 y); DHs: 329 (328 F+1 M; mean age 37.62 y)	—	—	NRL hypersensitivity reactions (type I)	Positive SPTs in dentists: 45 out of 888 in 1994 (5.1%); 48 out of 714 in 1995 (6.7%). Positive SPTs in DHs: 18 out of 186 in 1994 (9.7%); 13 out of 143 in 1995 (9.1%). SPT positive participants: 5.4% (2000); 4.8% (2001); 3.4% (2002)	Hamann et al <sup>13</sup>
ADHA national meetings in Washington, Nashville, Los Angeles, USA	Cross-sectional	2000-2002	Total OHPs: 582 (98% F; mean age ~40 y); DHs: 86% of the total participants	Hay fever, asthma, eczema, contact dermatitis (46%); Reactions to food, medication plants, insects, chemical and dental materials (74%). Atopic eczema in DH group: 17.1%	Full time work in general dentistry practices (30 h/week for 44 weeks per year)	NRL hypersensitivity reactions (type I)		Hamann et al <sup>12</sup>
Uppsala, Sweden	Cross-sectional	September 1996-June 1997	Total OHPs: 527; Dentists: 192, nurses: 269, DHs: 64, administrative employees: 2.		Less than 50% of DHs worked full time	Dental allergen hypersensitivity reactions	Itching of the hands: 33.9% dentists, 33.1% nurses, 25% DHs. Urticaria of the hands: 18.2% dentists, 13.8% nurses, 12.5% DHs. Acrylate allergy: 9.8% among patients with eczema (n. 41 out of 527 participants) Positive RAST test for NRL allergy: 10.2% dentists; 6.0% nurses; 4.4% DHs	Lindberg and Silverdahl <sup>15</sup>

Table continued

**Table 1 (Continued).** Summary of the studies analyzing possible chemical risks in DH occupational exposure settings.

Study setting	Study type	Period of investigation	Studied population	Pre-existing conditions	Task details	Outcome	Results	Reference
Värmland county, Örebro, Sweden	Cross-sectional	–	Total OHPs: 675 Dentists: 183, Nurses: 378, DHs: 114 (all F)	–	Workers from the public and private dental care sectors	NRL hypersensitivity reactions (type I)	Self-reported work-related allergy symptoms: 23 dentists, 39 nurses, 13 DHs. NRL-SPT positive participants: dentists: 9, nurses: 12, DHs: 4 Chemical dermatoses of hands and fingers (37%). Latex gloves were responsible for 1/3 of these reactions.	Ohlson et al <sup>16</sup>
Norway	Cross-sectional	–	DHs: 189	–	Active members of the Norwegian Association of Dental Hygienists	Chemically induced health complaints	Median DH head hair mercury concentrations: 2.1, 2.0, 0.4, 0.4 µg/g from 1970s to 2000s. Median DH pubic hair mercury concentrations: 2.1, 1.1, 0.6, 0.6 µg/g from 1970s to 2000s. Median fingernail DH mercury concentrations: 2.7, 2.2, 0.8, 0.8 µg/g from 1970s to 2000s. Median toenail DH mercury concentrations: 2.2, 1.1, 0.4, 0.2 µg/g in 1970s to 2000s	Jacobsen and Hensten-Petersen <sup>17</sup>
Scotland, UK	Prospective study	1975–2010	DHs examined for head hair mercury levels were 15, 117, 345, and 1651 for 1970, 1980, 1990 and 2000 decades, respectively	–	Workers from the public and private dental care sectors	Biological monitoring of hazardous substances	Mean mercury levels: 14.8 nmol/L (blood), 6.6 nmol/L (plasma), 1.8 µmol/mol creatinuria (urine). No association between musculoskeletal symptoms and mercury levels could be detected.	Duncan et al <sup>20</sup>
Blekinge, Sweden	Cross-sectional	–	DHs: 32 (all F; mean age 40.6 y). Medical nurses as referents: 30 (all F, mean age: 41.7 y)	–	DHs in the public dental health service. Mean h worked/week: 33.8. Mean employment duration: 90 months. 1 monitoring	Musculoskeletal symptom association with hazardous substance biological monitoring	Mean mercury levels: 14.8 nmol/L (blood), 6.6 nmol/L (plasma), 1.8 µmol/mol creatinuria (urine). No association between musculoskeletal symptoms and mercury levels could be detected.	Akesson et al <sup>21</sup>

ADA, American Dental Association; ADHA, American Dental Hygienists Association; DH, dental hygienist; NRL, natural rubber latex; OHP, oral healthcare professional; SPT, skin prick test.

ed the possible influencing role of different glove brand selection in determining such results. The importance of the type of gloves used, was also confirmed by Boyer et al<sup>14</sup> who demonstrated a significant reduction in dermatological signs and symptoms in 85 DHs with a self-reported history of hand irritation from medical glove use, when new low-chemical, low-protein, powder-free latex medical gloves were employed (symptom-free DHs: 41.2% at baseline; 61.2% post 6-month-use).

In Sweden, Lindberg and Silverdahl<sup>15</sup>, investigated NRL allergy in a study of 527 dental professionals, including 45 DHs. Among the DH sub-group, 29.7% claimed to have ever had eczema of hands, 76.6% reported allergic skin symptoms in general; while 25% of DHs claimed they had itching and 12.5% urticaria of the hands after using gloves. Concerning RAST test results, significant differences were evident between three oral health professions. Indeed, positive reactions were detected in 10.2% of dentists (13 of 128 tested), 6.0% of nurses (13 of 216 tested), and 4.4% of DHs (2 of 45 tested), maybe in relation to the differences in the frequency of glove use between the worker groups considered. Ohlson et al<sup>16</sup> evaluated the presence of possible NRL allergic effects on 114 Swedish DHs. Work-related allergy symptoms were reported by 13 DHs (11%), more in public dental care employees (n. 10), compared to those working in the private sector (n. 3). Out of the DH population surveyed through SPTs, 4 professionals tested positive. These results are in line with those previously obtained in 189 Norwegian DHs<sup>17</sup> who manifested chemical induced dermatoses of hands and fingers in 37% of cases, in which NRL gloves were responsible for one third of the reactions.

### ***Exposure to Other Chemicals***

Other dental products, such as composite resins and dentin bonding agents, can cause occupational allergic contact dermatitis<sup>18</sup>. The above-mentioned study by Lindberd and Silverdahl<sup>15</sup> also dealt with the exposure of the participants to acrylic resins. However, no specific reference to the DH subgroup could be definitively extrapolated in relation to allergic manifestations. Comparably, Hill et al<sup>11</sup> also analysed DH exposure to other chemical substances than NRL, i.e., acrylic resins and glutaraldehyde, but failed to report positive results.

Dental care professionals have been working with significant quantities of mercury, the main constituent of amalgam on a daily basis, and

cases of mercury poisoning have occurred, especially in dentists<sup>19</sup>. Concerning metal exposure, Duncan et al<sup>20</sup> monitored mercury exposure over a period of 35 years ranging from 1975 to 2010, both through environmental and biological monitoring. The aim was to inform dental staff of their exposure to mercury and to reduce exposure concentrations when biological monitoring findings were considered elevated. Mercury exposure in Scottish dental practice has become very trifling over the period of time investigated. In fact, the authors pointed out a noticeable decrease in exposure over the period investigated. During the first two decades of investigation, median mercury concentrations in all samples collected were higher than in more recent years. The main reason for the decrease of mercury concentrations, exposure, and contamination was likely due to the increased awareness of the dangers of mercury. This has led to the introduction of safer ways of preparing amalgam, as well as the progressive reduction in the use of such restorative material in favour of composite adhesive systems. Interestingly, in 1970s, DHs and administrative staff had comparable hair and nail concentrations to dentists and dental nurses. This may be due to less stringent delineations of working responsibilities among dental staff professionals. Reception staff, in fact, could also cover dental nurse duties. No significant differences were noted between biological monitoring in DHs and administrative staff, maybe in relation to the expected no direct exposure to mercury of both these groups. Additionally, Akesson et al<sup>21</sup> examined the correlation between exposure to mercury and its interaction with selenium and musculoskeletal disorders in 32 DHs. However, although DHs reported the highest prevalence of musculoskeletal symptoms compared to other investigated groups of dental care professionals, no correlation with mercury exposure could be demonstrated.

### **Discussion**

Dental hygienists play a key function in the diagnosis, prevention, and treatment of many diseases of the oral cavity. They also contribute to different organizational and operational activities, e.g., cleaning, disinfection, and sterilization of the instruments, in public and private professional structures. Therefore, such professionals are expected to become in contact with several chemicals, which may be potentially harmful

for the health of chronically exposed subjects. Nevertheless, few studies explored chemical risks occupationally experienced by DHs. This review represents the first attempt to systematically address this topic, with the aim to point out issues relevant to achieve a suitable evaluation of risks in such peculiar occupational settings.

However, this seems a challenging issue due to the lack of homogeneity in DH job tasks in different countries worldwide. This may be related to the different legislation licensing their practice, and the fact that DHs are poorly represented, not individually grouped, and principally assimilated to other dental professionals in epidemiological studies. Additionally, DHs primarily work at a free-professional level, and not in public health facilities, where there is a generally greater surveillance to the occupational health. This issue may have limited their enrolment in epidemiological investigations characterizing a possible "selection bias" in study samples. Moreover, the difficulty in clearly distinguishing among different groups of study participants prevents to specifically define DH chemical risks, as well as to specifically assess possible adverse health outcomes. All these aspects may explain the limited number of studies we could include in our review. Additionally, the cross-sectional nature of all but one of the reviewed articles may prevent a suitable comprehension of the exposure-response relationship in such peculiar chemical exposure context. Moreover, none of the reviewed studies addressed the issue of the chemical risks in DH practice according to a comprehensive and toxicologically standardised approach. This prevents the development of appropriate awareness in the DH workforce concerning the possibility for hazardous exposure and adverse health effects, as well as the adoption of suitable strategies for the protection of their safety and health<sup>11</sup>.

Overall, only limited and fragmented data are currently available on few possible hazardous exposures, including NRL, acrylate, and mercury exposure. The reason supporting the great interest in NRL adverse effects may be justified by the fact that it is the largest component of gloves, widely used as a personal protective equipment by oral care personals. Concerning NRL adverse reactions, these may be categorized as immunologic, i.e., IgE-mediated hypersensitivity and delayed cell-mediated reaction, as well as non-immunologic irritative reactions<sup>22-25</sup>. Dental hygienists should be deeply informed of possible

sources of NRL allergens in their practice and to avoid exposure as the only effective measure to prevent hypersensitivity reactions<sup>17</sup>. Furthermore, to identify potentially allergic workers, as well as educating them about the management of hazardous substances they are daily in contact, may be important to prevent the development of severe adverse reactions, as well as the worsening of yet compromised clinical conditions. As a primary preventive measure, to wear gloves made of synthetic non-NRL materials may be considered a possible solution to avoid NRL exposure. However, it may be important to take also in consideration possible risks derived from NRL proteins aerosolized from powdered NRL gloves worn by surrounding co-workers<sup>26</sup>. Dental office carpet, cabinetry, furniture, and air ventilation systems may characterize a possible source of deposition/reservoir of particulate matter contaminated with NRL proteins<sup>27</sup>. Moreover, an effective allergy management protocols in oral care occupational fields, should be strongly pursued. This should include efforts to assess the risk of NRL allergy in personals; the adoption of measures to identify, substitute, and isolate NRL containing products; the development of management regimens specifically focused on NRL-allergic workers; education and training about NRL allergy; and emergency training for possible adverse reactions<sup>28-30</sup>. Additionally, exposure to several skin irritants such as frequent abrasive-hand washing, hand disinfectants, and antimicrobial agents, pharmaceutical preparations, preservatives in skin care products and other chemicals used in health-care situations should be deeply assessed as possible co-exposure conditions functioning as co-factors in inducing allergic/irritative reactions<sup>15,31-33</sup>.

Dental personnel can be exposed to many other materials during their job tasks, including metals, acrylic compounds, antimicrobial, and pharmacological solutions, as well as different materials employed for dental restoration<sup>15,20,34,35</sup>. In this field, a rapid development in the type of materials used for this kind of practice has been experienced. This regards, i.e., the employment of various types of acrylates, which may be a cause of skin and respiratory allergies among dental personnel in relation to their ability to penetrate through both NRL and vinyl gloves within minutes of exposure<sup>36</sup>.

Interestingly, better understanding of hazardous effects of chemical substances, as occurred for mercury in amalgam restorative

materials, allowed to upgrade and renew dental practices, leading to a dramatically decreased levels of exposure to the metal over years as detailed by Duncan et al<sup>20</sup>. In this perspective, it may be important to develop environmental and biological monitoring plans to identify any exposure and early effect biomarkers to routinely support risk evaluation procedures in workplaces. This appears essential to adequately define the toxicological profile of the substances, levels of current exposure, dose-response relationships, and to achieve a better risk characterization. A more standardised approach to risk assessment procedures in DH field may be helpful in overcoming current lack of knowledge concerning possible risks derived from the exposure to materials daily employed in DH practice, polish made of silica, granulated zirconium silicates, flavoured excipients, and hydrogen peroxide<sup>15</sup>, as well as from materials of the latest generation, like compounds at the nanoscale, whose application in oral care is increasing, although their risk profile is still under investigation.

## Conclusions

Some critical issues could be pointed out from this review that needs to be addressed in future studies. Investigations specifically focused on the comprehensive evaluation of chemical risks for DHs in comparison to other oral care professionals should be planned. Methodological designs for substances currently employed in DH practice, but not yet sufficiently evaluated, as well as for those of more recent introduction, should include a prospective longitudinal approach, as well as a suitable assessment of exposure levels *via* environmental and biological monitoring. Overall, this information should be aimed to achieve a suitable assessment of chemical risks in oral care occupational field to define suitable preventive and protective measures, including collective and individual devices to control occupational exposure, workforce information and training, as well as specific health surveillance plans to adequately protect the health and safety of DHs.

## Conflict of Interest

The Authors declare that they have no conflict of interests.

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