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OCCUPATIONAL ALLERGIES (JA POOLE, SECTION EDITOR)

Recent Trends in Occupational Contact Dermatitis

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Abstract Occupational contact dermatitis (OCD) remains prevalent among workers and impacts quality of life and workability. The purpose of this review is to summarize the recent advances in occupational contact dermatitis as well as potential hazardous agents in the workplaces causing OCD. The review covers new developments in the epidemiology, etiology, diagnosis, and management of occupational contact dermatitis. This article also provides updated information on the prevalence of work-related skin symptoms and on new contact allergens among working population. It is emphasized that in the context of prevention of OCD, special attention should be focused on the identified high-risk occupational groups, especially healthcare workers and hairdressers starting with the apprentices. Current approaches include working out the standards and guidelines to improve the education, knowledge, diagnosis, and management of OCD based on a multidisciplinary team of medical specialists and an employer.

Keywords Occupational contact dermatitis · Diagnosis · Prevention · Management · Skin · Contact allergens

Introduction

Occupational contact dermatitis (OCD) is an inflammatory disease related to workplace exposure [1]. It is estimated that more than 13 million workers in the USA are potentially exposed to chemicals that can be absorbed through the skin. OCD is the most frequently recognized occupational disease in many countries, with estimated annual costs exceeding $1 billion [2]. On the other hand, recent comparisons of the trends in incidence of occupational diseases between 10 European countries revealed a significant decline in incidence of physician-reported and of recognized compensation claims for contact dermatitis in most countries, except Norway, France, and the Netherlands. In the UK and the Czech Republic, there is an observed decline in allergic but not irritant contact dermatitis [3••].

According to British Association of Dermatologists, contact dermatitis may be classified as subjective irritancy, acute irritant contact dermatitis, chronic irritant contact dermatitis, allergic contact dermatitis, phototoxic, photoallergic, and photoaggravated contact dermatitis, or systemic contact dermatitis (Table 1). Additionally, Dipgen et al. proposed a classification system for hand eczema, which is suggested to be used in clinical work and in clinical trials [4].

The purpose of this study is to present advances from recently published articles concerning occupational contact dermatitis.

Epidemiology and Etiology

Some occupations due to daily exposure to various chemicals and allergens are consequently at risk of occupational skin diseases (OSD). The latest data collected by the European Surveillance System on Contact Allergy network from 2002 to 2010 from 11 European countries revealed that thiuram rubber chemical accelerators, epoxy resin, and the antimicrobials methylchloroisothiazolinone/methylisothiazolinone, methyldibromo glutaronitrile, and formaldehyde are

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Table 1 Classification of contact dermatitis according to the British Association of Dermatologists statement—examples [according to [20]]

Contact dermatitis types	The result of	Causative agents
Subjective irritancy	Idiosyncratic stinging and smarting reactions	Cosmetic or sunscreen constituents
Acute irritant contact dermatitis	A single overwhelming exposure or a few brief exposures	Strong irritants or caustic agents
Chronic (cumulative) irritant contact dermatitis	Following repetitive exposure	Weaker irritants which may be either "wet," such as detergents, organic solvents, soaps, weak acids and alkalis, or "dry", such as low humidity air, heat, powders, and dusts
Allergic contact dermatitis	Sensitization of the immune system to a specific allergen or allergens	Metals, epoxy and acrylic resins, rubber additives, chemical intermediates
Phototoxic, photoallergic, and photoaggravated contact dermatitis	Erythematous skin reactions activated by solar radiation	Some allergens that are also photoallergens
Systemic contact dermatitis	After the systemic administration	Usually a drug, to which topical sensitization has previously occurred

associated with an at least doubled risk of OCD [5]. The highest risk of OCD was found in occupations classified as "other personal services workers," which include hairdressers, nursing and other healthcare professionals, precision workers in metal and related materials, and blacksmiths, tool-makers, and related trades workers [5]. Professions at high risk of severe OCD were found among female cooks, butchers, beauticians, bakers, and hairdressers, ranging from 23.3 to 96.8 cases per 10,000 workers per year, while among males at high risk were painters, cooks, mechanics, locksmiths, and bakers, ranging from 16.5 to 32.3 cases per 10,000 workers per year [6••]. Contact dermatitis was also diagnosed in 5.9 % workers of automotive repair industry, especially among auto tire workers (11.1 %) and auto exhaust repairmen (9.5 %) [7].

However, the data collected from the French National Network of Occupational Disease Vigilance and Prevention has shown that notified occupational allergic contact dermatitis (OACD) incidence was temporally stable over the period 2001–2010, but increases in OACD related to isothiazolinones, epoxy resins, and fragrances could be observed. Conversely, decreases were noted for cement compounds and plant products. The most frequent occupations with diagnosed OACD were hairdressers, healthcare workers (HCWs), cleaning staff, and masons [8••].

In Diepgen's summary of the epidemiological studies in Germany, nearly 80 % of occupational skin diseases occur in only seven occupational groups: hairdressers, metal workers, HCWs, food industry workers, construction workers, cleaners, and painters [9].

Thousands of different products including medicines, antioxidants, preservatives, antiseptics, biocides, pesticides, disinfectants and cleaning agents, metals, constituents of plastic and rubber materials, oils, pigments and dyes, cosmetics, depilatory waxes, Peru balsam, rosin, turpentine, plant (latex), and animal proteins and enzymes may trigger sensitisation resulting in allergic contact dermatitis. Among them, carba mix, thiuram mix, epoxy resin, formaldehyde, and nickel were the most common allergens causing OCD [1, 10, 11••]. Furthermore, for airborne contact dermatitis, drugs and preservatives have recently become one of the most frequent identified allergens [12•]. The recently identified occupational allergens causing OCD are summarized in Table 2.

Interestingly, drugs are becoming the crucial group of OCD allergens. For example, the sensitizing potential of omeprazole as contact allergen and via airborne exposure was reported [13–15]. Tetrazepam has increasingly been described as an important occupational allergen in this regard; e.g., crushing drug tablets has been source of allergens to cause OCD; moreover, in contrast to systemic drug reactions, other benzodiazepines may cross-react following skin exposure [16].

The metalworking fluids were found to be the most frequent cause of OCD in three regions of central Slovakia [17]. Additionally, in the retrospective epidemiological analysis, the allergens significantly associated with the occupational group of blue-collar workers were epoxy resins, methyldibromo glutaronitrile, 2-bromo-2-nitro-1,3-propanediol, potassium dichromate, and methylchloroisothiazolinone/methylisothiazolinone [18••].

Atopic dermatitis, contact allergy, age, and sex have been identified as the individual risk factors of OCD. Moreover, some occupations (e.g., painters and beauticians) were also identified as providing risk for methylisothiazolinone sensitization [19]. The jobs like painting, construction work, and tile setting/terrazzo work were recognized as increasing risk of contact sensitization to methylchloroisothiazolinone and methylisothiazolinone, epoxy resins, and potassium dichromate [18••].

Irritant contact dermatitis is a common diagnosis in patients with OCD. The most common agents causing it are soaps, detergents, and water, while in occupational settings oils, coolants, alkalis, acids, and solvents [20]. In Friis et al.'s study, the main causative irritant exposures identified were wet work, glove use, mechanical traumas, and oils. The exposure

Table 2 Recent reports about new occupational allergens on allergic contact dermatitis

First author, year	Type of new allergen	Type of occupational exposure	Study population	Symptom localization	Assessment of contact dermatitis (patch testing)
Wootton, 2012 [59]	Oxycodone	Pharmaceutical laboratory scientists, manufacturing operative	3 individual cases	Face and/or hands	Oxycodone in crushed tablet or liquid form
Brans, 2012 [60]	(R)-3-(2-chloro-1-hydroxyethyl)-phenol (HCPE)	Chemical worker	Case report	Hands and lower arms	HCPE (1, 5, and 10 % pet.)
Stenveld, 2012 [61]	Aluminum chloride	Swimming instructor	Case report	Entire body	Locron® L—flocculant based on aluminum chlorohydrate (2 % aqua)
Baeck, 2013 [62]	Latex (natural rubber)-free gloves	Healthcare workers	8 individual cases	Hand eczema	Parts of synthetic gloves
Aalto-Korte, 2013 [63]	Ethanolamine derivative of tall oil fatty acids	Machinist	Case report	Hand dermatitis	Patient's own metalworking fluid (10, 3.2, and 1 % pet.)
Hald, 2013 [64]	Black rubber products	Trainee in a company selling plumbing supplies	Case report	Hands and subsequently on the feet, arms, and legs	N-cyclohexyl-N-phenyl-p-phenylenediamine (CPPD), N-isopropyl-N-phenyl-p-phenylenediamine (IPPD), and 4,4-diaminodiphenylmethane, compounds used in black rubbers
Paulsen, 2013 [65]	Calocephalin allergen from Cushion bush: *Leucophyta brownii Cass.* = *Calocephalus brownii (Cass.)*		Series of cases		Calocephalin 0.1 % ethanol
De Mozzi, 2013 [66]	Citral (CAS no. 5392-40-5)	SPA beauticians	Series of 9 cases	Dorsum of hands, fingers, in some cases the wrists and forearms	Fragrance mix II 14 % pet. and citral 2.0 % pet.
Bonny, 2014 [67]	Pao ferro—tropical wood	Woodworker	2 cases	Hands, arms, face, chest and genitals	Santos rosewood
Byun, 2014 [68]	Trifluoroacetic acid (TFA)	Laboratory technician	Case report	Forehead, neck, and forearms	TFA 1 %. aqua
Foti, 2014 [69]	Eustoma exaltatum ssp. russellianum	Floriculturist	Case report	Hands, forearms, and face	Patch test reaction (++) to lisianthus flower
Hagvall, 2014 [70]	Sodium cocoamphopropionate—surfactant	Fast food restaurant workers	2 cases	Hands	Positive reactions to the soap and to sodium cocoamphopropionate 1 % aq.
De Quintana Sancho, 2014 [71]	N,N-didecyl-N-methyl-poly(oxyethyl) ammonium propionate—quaternary ammonium compound	A dental clinic worker	Case report	Right wrist	Positive reactions to 1 % Darodor Sinaldehyd 2000® and to 5 % N,N-didecyl-N-methyl-poly(oxyethyl) ammonium propionate
Paulsen, 2014 [72]	Yucca (*Yucca gigantean* Lem.)	Plant caretaker	Case report	Hands, arms, and legs	Yucca leaf wetted with water
Andersen, 2014 [73]	*Telekia speciosa*, *Vicia hirsuta*, *Filipendula ulmaria*	Woodman	Case report	Facial dermatitis and skin eruption on the neck, arms, hands, lower leg	Application of five fresh plants
Crépy, 2014 [74]	Tricresyl phosphate in polyvinylchloride gloves	Hospital cleaner	Case report	Hand, wrists, and forearms	The piece of vinyl glove (++), tricresyl phosphate (TCP) 5 % pet. (+++), thiuram mix 1 % pet. (+++), stearyl alcohol 30 % pet. (++).
Burches, 2014 [75]	Sevoflurane—halogenated anesthetic agents	Surgeon	Case report	Thighs, groin, anogenital area, the eruption spread	Repeated open application test with sevoflurane and desflurane

Table 2 (continued)

First author, year	Type of new allergen	Type of occupational exposure	Study population	Symptom localization	Assessment of contact dermatitis (patch testing)
				onto abdomen, face, and flexures	
Suuronen, 2014 [76]	Caprylediethanolamine	Machinist and a borer and filer-machinist	2 cases	Hands	Caprylediethanolamine: 2, 1, 0.32, 0.1, and 0.032 % (tested in pet.)
Madsen, 2014 [77]	Methylisothiazolinone in an ultrasound gel	Nurse	Case report	Hands and the right forearm	EKO GEL® (+/++), methylchloroisothiazolinone/ MI 4 μg/cm^2 (++/+), and MI 0.2 % aq. (+++/+++)
Dahlin, 2014 [78]	Triphenylguanidine—rubber accelerator	Surgeon and surgical scrub nurse	2 cases	Hands	1 % 1,3-diphenylguanidine pet. (++), 1.35 % triphenylguanidine pet. (+)
Al-Falah, 2014 [15]	Omeprazole	Horse breeder	Case report	Eyelids, face, neck, and forearms	Three concentrations of GastroGard® and with two concentrations (10 and 1 % in pet. prepared from crushed tablets)

to specific irritant chemicals was recognized mainly through the material safety data sheets/ingredients lists [21].

Diagnosis

Epicutaneously applied patch tests are the standardized diagnostic procedures to confirm allergic contact dermatitis [1]. Recommendations of the British Association of Dermatologists included patch testing to at least an extended standard series of allergens in patients with persistent eczematous eruptions [11••, 20]. It is established that a screening battery of patch tests is best developed by using standardized sets of allergens previously calibrated with respect to nonirritant concentrations and compatibility with the test vehicle. Reading and interpretation of patch tests should conform to principles developed by the International Contact Dermatitis Research Group and the North American Contact Dermatitis Research Group [1].

The patch test procedures have been improved over the years. Apart from standard series of allergens used for patch testing, a new hypothetical screening series is investigated to increase diagnostic accuracy. The research of Christoffers et al. evaluating whether it is relevant to add isobornyl acrylate to the (meth)acrylate test series revealed that isobornyl acrylate contact allergy seems to be rare, although this allergen should be considered as a potential sensitizer in individual cases. However, there is insufficient support for isobornyl acrylate to be routinely used in the (meth)acrylate patch test series [22].

In addition to standard diagnostic procedures, the new tools for the diagnosis and classification of chronic hand eczema are developed. Molin et al. have proposed a short and new graphical algorithm that is useful as a clear decision tool for diagnosing chronic hand eczema in clinical practice. The algorithm distinguished chronic hand eczema due to contact allergy, irritant damage, or a combination of the two, each either with or without atopy [23].

It is strongly emphasized that for the accurate diagnosis of OCD, it is essential to assess the exposure to the relevant allergen. Therefore, the patch testing including the patients' own products as well as chemical analysis of the products from the workplace is required. Additionally, Material Safety Data Sheets (MSDS) are considered as important source of information concerning exposures in the workplace. On the other hand, Friis et al. concluded that the insufficiencies in the MSDS are a result of the "self-classification," as not all known allergens need to be labelled and because a labelling concentration is too high in relation to the level of elicitation [24].

Systematic exposure assessment provides information that leads to the identification of occupational allergies caused by allergens not included in the European baseline series [25].

Management and Prevention

Similarly like in the case of other occupational diseases, management of OSD comprises medical treatment and workplace interventions. While medical treatment does not differ from general rules, the identification and avoidance of contact with the offending agent(s) are key to the success of allergic contact dermatitis treatment [1]. Moreover, visiting the workplace may be essential in the effective treatment and prevention of contact dermatitis. It enables identifying potential allergens and irritants [20].

Key recommendations from the British Occupational Health Research Foundation bases on systematic review concerning occupational contact dermatitis and urticaria published recently [11••] focus on employers and their health and safety personnel, as well as health practitioners' responsibilities.

A group in the Netherlands has proven the efficacy of a model of a multidisciplinary care team aimed to integrate clinical and occupational care to optimize treatment and self-management. The intervention comprised an evaluation by a dermatologist, education by a specialist nurse, and participation of an occupational physician for work issues. An integrated care was directed towards minimizing a worker's exposure to allergens and irritants, by eliminating them or using the appropriate protection measures, both at the workplace and at home. The effectiveness of such a multidisciplinary intervention was evaluated in a randomized controlled trial. It was found that such a model had a positive effect on the clinical severity score (HECSI) for patients with different degrees of chronic hand eczema after 26 weeks. The integrated care intervention was not effective in improving quality of life, nor in cumulative days of sick leave [26••].

Another paper of the same group [27] has revealed good satisfaction of both patients and healthcare professionals with the integrated care program. They considered the multidisciplinary approach and good communication as positive, as well as the time available for patients. However, some limitations of the protocol were indicated. The occupational physician was not involved in all cases referred to occupational care, the protocol was perceived as not flexible, and the intervention period was perceived as too compact.

Lack of awareness of OSD seems to be a key barrier to prevention. Holness and Kudla found that a proportion of workers from a variety of industries did not get complete education related to prevention of skin exposure. Moreover, workers in unionized workplaces were more likely to report the presence of prevention practices. On the other hand, workers exposed to wet work were less likely to report training related to skin protection and glove use [28].

Also, study of Clemmensen et al. indicates a positive effect of a low-cost on-site educational intervention (1-h course in hand-protective behavior) for hospital cleaners. The effect could be seen on behavior, knowledge, and decrease in skin symptoms when re-investigated after 3 months [29].

In randomized clinical trial, Ibler et al. reported that secondary prevention program for hand eczema improved severity and quality of life and had a positive effect on self-evaluated severity and skin-protective behavior by hand washings and wearing of protective gloves among HCWs [30]

As workplace cleansers may play a role in the development of irritant dermatitis, Elsner et al. proposed that the intrinsic irritation potential of a cleanser should be taken into account and also a standardized, validated testing procedure for the assessment of occupational cleanser irritancy with generic reference standards could be implemented to reduce the incidence of occupational irritant dermatitis [31].

The other independent issue is the long-term prognosis for OCD that is often very poor. It was established that avoiding the cause of the contact dermatitis or even changing the occupation had not improved the prognosis and the majority of the patients had the periodic or permanent symptoms [20].

Van der Meer et al. reported that although the intervention group showed a negative effect for self-reported hand eczema as compared with the control group, the multifaceted implementation strategy was effective in implementing evidence-based recommendations for hand eczema in a healthcare setting. Therefore, the strategy can be used in practice, because it showed positive effects on preventive behavior—such as hand washing (reduction), the use of a moisturizer, and the use of cotton undergloves—and this behavior is based on evidence-based recommendations for the prevention of hand eczema [32].

Antelmi et al. evaluated the protective properties of gloves against an oxidative hair dye containing PPD, in hairdressers already sensitized to PPD, simulating their regular use as protection during the performance of an occupational task. The authors found eczematous reactions when natural rubber latex, polyethylene, and vinyl gloves were tested with the dye. The nitrile gloves gave good protection, even after 60 min of exposure to the hair dye. Many protective gloves used by hairdressers were found to be unsuitable for protection against the risk of elicitation of allergic contact dermatitis caused by PPD [33].

Weisshaar et al. performed the largest and most comprehensively documented intervention study in a cohort of patients with refractory OSD. This 12-month follow-up study revealed the persistence of the previously reported more immediate reductions in severity of OSD, topical steroid use, and number of days of absence from work and improvements in quality of life. These results indicated that the tertiary individual prevention [dermatological treatment and diagnostic procedures and patient education (health and psychological)] provided a reduction in the personal and public burden of OSD [34].

A graphic model of a multidisciplinary management of OSD comprising medical specialists and an employer has been proposed in Fig. 1.

Recent Findings

Recently, groups at high risk of OCD are gaining growing interest. In Mirabelli et al.'s study, hand dermatitis was reported by 28 % of current cleaning workers and associated with cleaning outdoor areas and schools and the use of hydrochloric acid and dust mop products. The authors drew attention to the lack of sufficient skin protection at work among these workers and emphasized the need of further investigation of the role of multiple product exposures and personal protective equipment [35].

In Warshaw et al.'s study, occupationally related skin disease was more common in food service workers when compared with non-food service workers. The rates for irritant and allergic contact dermatitis in food service workers were 30.6 and 54.7 %, respectively. In this occupation, the most frequent currently relevant were thiuram mix (32.5 %) and carba mix (28.9 %), while gloves were the most common source of responsible allergens [36].

Machinists are exposed to many sensitizing and irritant substances. Hannu et al. examined the occurrence of skin diseases in a large sample of machinists in southern Finland. They found seven cases of occupational dermatitis, giving a prevalence of 0.92 %, which leads to the conclusion that the rather low occurrence of OCD may reflect the strict diagnostic criteria for occupational diseases in Finland, as well as the relatively good level of occupational hygiene in machine shops in Finland [37].

Aalto-Korte et al. reported that cocamide diethanolamine contact allergy is relatively common in patients with OSD. Hand cleansers at the workplace constitute the main source of sensitization, but detergents, metalworking fluids, and barrier creams also need to be taken into account, and concomitant reactions to ethanolamines are possible [38].

Carøe et al. have prepared an overview of exposures for patients with OCD in Denmark in 2010. Irritant contact dermatitis accounted for 70 % of all cases; 68 % of these were caused by wet work. Seventy-six percent of all patients were employed either in the healthcare sector, in cleaning or as kitchen workers. Among contact allergies, the most common were to rubber additives from gloves and epoxy in patients employed in the windmill industry. Since the workers in the healthcare sector, kitchen workers, and cleaners constitute almost half of all cases, it seems the future preventive efforts should be directed at these occupations [39].

The study among 300 workers of a vehicle equipment factory, exposed to polyurethane foam, based on 4,4′-diphenylmethane diisocyanate (MDI) revealed presence of current eczema in the area of hands and/or forearms, diagnosed as OACD in 7 workers, irritant contact dermatitis in 10, and coexisting allergic and irritant contact dermatitis in 3 subjects. It was highlighted that work-related skin problems should be probably attributed to insufficient skin protection [40].

According to Diepgen et al., the costs of occupational hand eczema were estimated to be at least as high as the costs of atopic dermatitis or moderate to severe psoriasis in Germany and amounted to €8799 per patient. The authors show the importance of occupational hand eczema with regard to the magnitude of the economic burden for individuals, health insurance providers, and society. Conversely, disease severity, although impacting on patients' impairment of quality of life, had little influence on treatment patterns and costs [41].

As epoxy resins are among the most important causes of allergic OCD, Aalto-Korte et al. described the exposure of patients reacting to diglycidyl ether of bisphenol F (DGEBF-R). Concomitant allergy to DGEBF-R and diglycidyl ether of bisphenol A resin (DGEBA-R) was common, owing to cross-allergy or simultaneous exposure, but independent contact

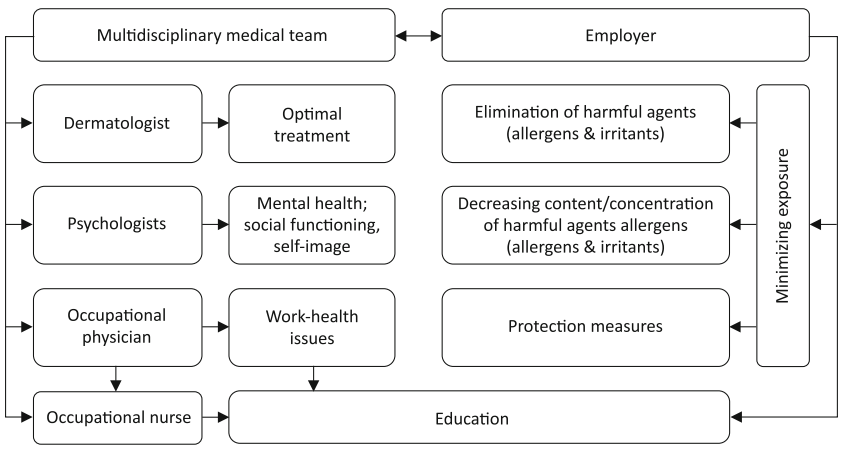

Fig. 1 A model of a multidisciplinary care team in management of occupational skin diseases [according to 26••, 79]

allergies to DGEBF-R were rare, despite the high number of products with DGEBF on the market. The screening with DGEBF-R was not found to be useful. In some cases, the diagnosis of occupational allergic contact dermatitis requires testing with DGEBF-R or with the patients' own DGEBF-based products [42].

Contact allergy may be work-related, and some occupational groups are more likely to develop nickel, cobalt, and chromium cosensitization. Rui et al. evaluated the patch test results from the large cohort to estimate the isolated and concurrent occurrence of nickel, cobalt, and chromium contact sensitization. They found that nickel sensitization was associated with metal and mechanical work as well as cleaning work. An association was found between isolated cobalt sensitization, textile, and leather work. The frequency of chromium allergy was found to be increased in building workers, metalworkers, bartenders, and cleaners. Building and related trades work was significantly associated with positive reactions to nickel plus chromium and chromium plus cobalt. Simultaneously, the textile and leather workers, cleaners, and bartenders showed an increased risk for concurrent sensitization to all three metals [43].

A retrospective epidemiological analysis showed that methylisothiazolinone sensitization was significantly associated with occupational exposures, which are tile setters/terrazzo workers, machine operators, and painters groups. Methylchloroisothiazolinone/methylisothiazolinone contact allergy was associated with high-risk professions like painting, welding (blacksmiths), machine operating, and cosmetology [44].

Limonene is a frequent occupational sensitizer for workers who use machine-cleaning detergents, hand cleansers, surface cleaners, and dishwashing liquids [45].

Hairdressers are still a frequent group under investigations. The common cause of contact dermatitis in hairdressers represents p-phenylenediamine and toluene-2.5-diamine in hair dyes and persulfates in bleaching products as well as glyceryl monothioglycolate. Hougaard et al. found that hand eczema was significantly more prevalent in the hairdressing apprentices than in controls (34.5 vs. 18.8 %), with the incidence rate of 98 cases/1000 person-years, increasing with elongating duration of exposure. The conclusion is that despite educational efforts to prevent OSD in the hairdressing schools, Danish apprentices are still at increased risk for hand eczema which usually develops after only a few years of work in hairdressing and further preventive strategies to reduce OSD in hairdressing apprentices are warranted [46].

Also, Lyons et al. among 157 trainee and qualified hairdressers with OCD found that in 71 %, allergic contact dermatitis was primarily diagnosed while irritant contact dermatitis in 20 %. Involvement of more than one body part was suggestive of allergic contact dermatitis, which was more common in apprentices than in qualified hairdressers. Ammonium persulfate, p-phenylenediamine, toluene-2,5-diamine, and glyceryl monothioglycolate were the most common occupational allergens. Nickel allergy was seen in 31 % of hairdressers but considered to be occupationally relevant in only 3 % [47].

The other study performed among hairdressers by Schwensen et al. confirmed p-phenylenediamine, thiuram mix, and benzocaine allergens as the most common allergens, but the other frequent ones were ammonium persulfate, toluene-2,5-diamine, 3-aminophenol, and 4-aminophenol. Cysteamine hydrochloride and chloroacetamide emerged as new sensitizers. It was also the first study demonstrating a healthy worker effect among educated hairdressers diagnosed with eczema; thus, it was concluded that career guidance among individuals with atopic dermatitis had a high priority in the future [48••].

Lyons et al.'s study performed among hairdressers and apprentices with a confirmed OCD suggested that claim rates reported in workers' compensation data sets underrepresent the true incidence of diagnosed OCD among hairdressers in Victoria, Australia. The median cost per claim was AU$1421, and the median time off work per claim was 20 days. It seemed that hairdressers might accept dermatitis as "part of the job," being unaware of their compensation entitlements or being put off by paperwork. Fear of job loss may act as a reporting disincentive, particularly among apprentices and part-time workers. Occupational health and safety authorities should be aware that workers' compensation statistics underestimate the impact of OCD in hairdressing [49].

The next occupation with the high interest of researchers was HCWs. Machovcová et al. (2013) reported a general downward trend of diagnosed cases of OSD in HCWs in the Czech Republic during the past 13 years. The overall incidence in individual years varied between 1.0 and 2.9 cases per 10,000 full-time employees per year. Disinfectants were the most frequent chemicals causing more than one third of all allergic skin diseases, followed by rubber components and cleaning agents [50].

The studies concerning OCD among HCWs have indicated the rubber accelerator 1.3-diphenylguanidine (DPG) as a relevant contact allergen in sterile protective polyisoprene gloves. Pontén et al. found a high number of positive test reactions to DPG and cetylpyridinium chloride, additionally demonstrating the presence of it in the gloves and the positive test results when testing with the gloves. The authors concluded that despite a very low number of contact allergies to sterile rubber gloves previously reported, during recent years a substantial increase could have been observed. This tendency is likely to be explained by the increased number of contact allergies to DPG [51].

Also, Molin et al. found that although in medical glove production thiurams have been replaced by dithiocarbamates,

they are still the most frequent rubber allergens in HCWs. Significantly increased sensitization rates were found for thiuram mix (6.7 %), potassium dichromate (5.7 %), methylchloroisothiazolinone/methylisothiazolinone (4.4 %), colophonium (3.4 %), 2-bromo-2-nitropropane-1.3-diol (1.7 %), and zinc diethyldithiocarbamate (1.7 %). Patch testing with products from the patients' workplaces gave additional clues to further allergens, while formaldehyde allergy seems to be less important today [52].

A prospective cohort study was performed among 721 Dutch apprentice nurses. The 1-year period prevalence of hand eczema was 23 % in the first year, 25 % in the second year, and 31 % in the third year of follow-up. Eighty-one new cases of hand eczema developed, most of which occurred during the first year. Frequent hand washing both during traineeships and at home or having a side job involving wet work were independent risk factors for hand eczema [53].

Ibler et al. in the cross-sectional study showed the 21 % prevalence of hand eczema in HCWs, which was twofold increased in comparison with the background population and positively correlated with atopic dermatitis, younger age, male sex (male doctors), and working hours. The relationship between fair skin and hand eczema has been suggested as a new trend. No significant differences were found between professions or medical specialties with respect to prevalence or severity, but cultural differences between professions with respect to coping with the eczema were significant. Atopic dermatitis was the only factor related to severity; thus, preventive efforts should be made for HCWs with atopic dermatitis [54].

The 1-year self-reported prevalence of hand eczema among healthcare professionals in the Dutch study was 12 %. Sick leave resulting from hand eczema was reported by 0.3 % of HCWs in general and by 1.7 % of healthcare professionals with hand eczema. In the group with hand eczema, 3.1 % reported a large effect on presenteeism. However, hand eczema at a population level seems to have had little impact on absenteeism and presenteeism in this study population [55].

Subjects with contact dermatitis are often exposed both to irritants and allergens in occupational settings. Schwensen et al. presented data obtained in a retrospective cohort on incidence rates for occupations diagnosed with combined allergic and irritant contact dermatitis. The expected number of cases with both diseases was 0.33 %, as compared with the observed number of 6.4 %, which indicates that this diagnosis should be assigned more rarely. Females engaged in wet occupations were often diagnosed with combined allergic and irritant contact dermatitis. The diagnosis of combined allergic and irritant contact dermatitis should be used critically to avoid misclassification [56].

The connection between skin and respiratory systems in occupational disease has recently gained an interest. Some common occupational contact allergens were determined to be established or possible causes of occupational asthma (epoxy resin, nickel sulate, cobalt chloride, potassium dichromate, PPD, formaldehyde, and glutaraldehyde), whereas for thiuram, carba mix, and glyceryl thioglycolate, no evidence of an association with occupational asthma was found [10]. It was reported that subjects with a history of eczema had significantly greater odds of reporting both work-related skin and respiratory symptoms. Additionally, subjects from larger workplaces and those who reported wearing a respirator while at work were more likely to report concurrent skin and respiratory symptoms. Also, current smoking was found to be associated with reporting concurrent skin and respiratory symptoms [57]. Moreover, Arrandale et al. found that reporting skin symptoms was strongly and consistently associated with respiratory symptoms in both bakery and auto body shop workers. In addition, exposure–response relationships for skin symptoms were observed in auto body shop workers; similar relations for work-related skin symptoms in bakery workers did not reach statistical significance. Thus, the association may have been missed in bakery workers, due to poor correlation between airborne and skin exposure for the particulate exposure and the lack of information on other, potentially causal, exposures in the workplace [58].

Conclusions

OCD remains prevalent among workers and considerably influences quality of life and workability. Dermatologists as well as occupational medicine physicians recognizing OCD should be particularly alert to the new workplace deriving allergens, as every year the emerging ones are described. The future research studies focused on multiple product exposures resulting in occupational contact dermatitis are needed. Additionally, as irritant contact dermatitis prevalence has increasing tendency, much more attention should be paid to the sufficient skin protection and prevention in occupational settings. Generally, the sustained improvement of a level of occupational hygiene comprising personal protective equipment can result in decreasing prevalence of OCD. It should be emphasized that in OCD prevention, identified high-risk occupational groups, specifically healthcare workers and hairdressers, including apprentices need special attitude. The standards and guidelines to improve the education, knowledge, diagnosis, and multidisciplinary management of OCD have been published recently and need to be routinely applied. Moreover, the legal aspects of workers' compensation in subjects with OCD as well as their return to work should be clearly regulated and implemented in everyday practice.

Compliance with Ethics Guidelines

Conflict of Interest Marta Wiszniewska and Jolanta Walusiak-Skorupa declare that they have no conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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