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Occupational allergic contact dermatitis: a 24-year, retrospective cohort study from Turkey

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Abstract

Background: Limited data exists on occupational allergic contact dermatitis (OACD) in Turkey.

Objectives: To investigate the epidemiologic profile of OACD in Turkey.

Methods: A retrospective cohort study on 294 patients with OACD among 2801 consecutively patch-tested patients in the allergy unit of the dermatology department of İstanbul Faculty of Medicine between 1996-2019.

Results: The overall prevalence of OACD was 10.5%, showing a male predominance. OACD was most frequently seen in construction workers (45.2%), followed by hairdressers, metalworkers, healthcare workers, and miscellaneous. The main relevant allergens were chromium in cement, thiurams in rubber gloves, hairdressing chemicals, resins/glues/plastics, metals, isothiazolinones, and fragrances. Hands were the mainly involved site (95.6%). Airborne eczema was observed in 21.4%. Hand&foot eczema and co-sensitizations to chrome&thiuram and chrome&cobalt were significantly associated with being a construction worker. Sensitizations to isothiazolinones in house painters, ammonium persulfate and p-phenylenediamine in hairdressers, and colophonium increased after 2010.

Conclusion: These were the largest data on OACD from Turkey, reflecting the importance of rubber glove allergy in all occupations and the striking increase in ammonium persulfate allergy among hairdressers. Chrome and cobalt were still the main cement allergens in Turkey, where the cement directive is not yet in force.

Keywords: allergic contact dermatitis, patch test, epidemiology, rubber chemicals, biocides, metals, occupational, construction worker, hairdresser, airborne eczema

1. Introduction

Occupational allergic contact dermatitis (OACD) is a significant health problem with socioeconomic consequences worldwide. The relevant occupations and allergens may vary from country to country. The cement directive in the European Union (EU Directive 2003/53/EC)¹ limiting the water-soluble hexavalent chromium content in cement to 2 ppm by adding mainly ferrous sulfate to cement significantly reduced the number of construction workers with OACD in many European countries.²⁻⁵ In Turkey, however, the cement directive is not yet in force and will be effective as of 31 December 2021 (personal communication with Turkish Cement Manufacturers' Association [TCMA]). As there are only limited data on OACD in our country, this study aimed to investigate the epidemiologic profile of OACD in Turkey within a relatively large period.

2. Methods

This was a single-center, retrospective cohort study based on the analysis of the files of 2801 patients who were consecutively patch tested in the allergy unit of the Department of Dermatology and Venereology of İstanbul Faculty of Medicine, a tertiary referral center, with suspicion of ACD/OACD between 1996 and 2019. Of these, 294 patients who were diagnosed with OACD were enrolled in the study.

Patch testing was performed after obtaining the oral or written consent of patients or legal guardians in those who were <18 years old. Test allergens were supplied by Chemotechnique Diagnostics (Vellinge, Sweden), Brial Allergen (Greven, Germany), AllergEAZE (Calgary, Canada), and in the earlier years by Hal-Brial (Leiden, the Netherlands). They were applied in IQ Chambers® (Chemotechnique Diagnostics) to the upper back for 48 hours. Patch tests were occluded with Hypafix® tape (BSN medical GmbH, Hamburg, Germany). In addition to our extended baseline series,⁶ patients were also patch tested with supplemental series and with their

own material, if necessary. Hair gel/wax, ultrasound gel, eye drop, topical medicament, shoe polish cream, adhesive tape/bandage, and wood dust were patch tested 'as is', the latter two first moistened with water. Cutting/cooling fluids were tested as clean and used samples in serial dilutions up to 5% aq. and 8% aq., respectively. Machine oil was tested as clean and used samples in serial dilutions up to 50% in olive oil. Rubber glove, rubber hose, steering wheel cover, and paper were patch tested for 72 h (in pieces of 2 x 2 cm² or larger, soaked in or moistened with water).

Test sites were evaluated at days (D) 2, 3, 4, and since 2010, at D7 as well, according to the ESCD patch test guideline.⁷ Positive patch test reactions were further interpreted with regard to clinical and occupational relevance according to history (showing a workplace-related course with exacerbations at the workplace and remissions at holidays), clinical findings, Mathias criteria,⁸ and product labels or material safety data sheets, if available. Only those who fulfilled the Mathias criteria, (1) consistency of the clinical appearance with contact dermatitis, (2) workplace exposure to potential cutaneous allergens, (3) consistency of the localization of dermatitis with cutaneous exposure concerning the job task, (4) temporal relationship between exposure and onset of contact dermatitis, (5) exclusion of nonoccupational exposures as probable causes, (6) improvement of dermatitis when away from work-related exposure to the allergen, (7) patch test results implicating a specific workplace exposure, were diagnosed with OACD. The MOAHLFAP index⁹ was calculated. The occupational titles were named according to the International Standard Classification of Occupations (ISCO-08) as recommended recently.¹⁰

An 'airborne type' of OACD^{11, 12} was diagnosed if (1) the lesions were located on air-exposed areas, e.g., face including the shaded areas such as the upper eyelids, behind the ears, nasolabial folds and skin creases, as well as the neck, the V-region of the chest, hands, wrists, and forearms, (2) if there was contact to a volatile occupational substance, e.g., hair bleach powder, cement

dust, and epoxy fumes, (3) if patch testing was positive with the known contact allergens in these volatile substances, (4) and if clinical and occupational relevance could be established.

Data were stored and assessed using IBM SPSS® Statistics Version 22. The χ^2 or Fisher's exact test was used for the comparison of categorical variables. A 2-tailed P -value $< .05$ was accepted as statistically significant. The Kruskal-Wallis test and a Bonferroni-adjusted Mann Whitney U test were used for comparison of non-parametric continuous variables. Multivariate analysis was used for identifying independent associations between co-sensitizations (chrome&cobalt or chrome&thiuram) and being a construction worker, as well as between hand&foot eczema and being a construction worker.

This study was approved by the local Ethical Committee (approval number: 2018/31) and conducted in accordance with the Declaration of Helsinki.

3. Results

The overall prevalence of OACD between 1996-2019 was 10.5% (294/2801). The male-female ratio was 4.8:1. OACD was most frequently seen in construction workers (45.2%), followed by hairdressers (18.7%), metalworkers (9.5%), healthcare workers (8.5%), and miscellaneous (18.1%). The demographic features according to occupations are shown in Table 1.

The onset of OACD (Table 1) was significantly later among construction workers ($P_c < .001$), and significantly earlier among hairdressers ($P_c < .001$) and healthcare workers ($P_c < .001$) (corrected P_c values $< .008$ according to Kruskal Wallis test and a Bonferroni-adjusted Mann Whitney U test, $\chi^2 = 44.0$, $df = 5$).

Atopic skin/AD was most frequently observed in hairdressers and female patients. Hands were the most frequently involved site ($n=281$, 95.6%) with/without involvement of other parts of the body, generalized eczema ($n=9$, 3.1%), isolated face/periorbital eczema ($n=2$, 0.7%), Baboon syndrome ($n=1$, 0.3%), and ankle eczema ($n=1$, 0.3%). Airborne dermatitis was seen in 63

(21.4%) patients (Table 2). The main relevant occupational allergens and products are shown in Table 1 and Table 3, the latter along with the ISCO-08 codes of occupational subgroups.

3.1 Construction workers

Construction workers were mainly sensitized with potassium dichromate in cement and rubber additives in nitrile-coated protective cotton gloves (Table 1 and 3) (Figure 1A-C). Logistic regression analysis showed that chromate-thiuram mix (Figure 1B), and chromate-cobalt allergies were independently associated with being a construction worker ($P < .001$, odds ratio: 93.8, 95% CI: 22.3-394.4 and $P < .001$, odds ratio: 17.1, 95% CI: 7.1-41.5, respectively). Moreover, the concomitant involvement of hand&foot was independently associated with being a construction worker ($P < .001$, odds ratio: 12.2, 95% CI: 3.6-41.4) (Figure 1A). MCI/MI and/or MI allergy from water-based wall paints in house painters significantly increased during 2010-2019 compared to 1996-2009 ($P < .01$).

3.2 Hairdressers

Sixteen of the 55 hairdressers (29.1%) were hairdresser apprentices (≤ 18 years old), and 70.9% ($n=39$) professionals (>18 years old). PPD/hair dyes and ammonium persulfate allergies were more frequent among hairdresser professionals (87.5% and 53.8%, respectively) than among apprentices (82.1% and 37.5%, respectively). The differences were statistically not significant. Men's barbers ($n=5$) were sensitized with MCI/MI $\pm$ formaldehyde/methyldibromo glutaronitrile (MDBGN)-containing hair gel/wax ($n=4$), and hair dye + shampoo ($n=1$). The number of hairdressers significantly increased during 2010-2019 ($P < .01$) in comparison to 1996-2009, together with a major increase of ammonium persulfate allergy to 2.4-fold, followed by an increase of PPD allergy to 1.4-fold.

3.3 Metalworkers

Metals (67.9%), particularly nickel sulfate, potassium dichromate, and cobalt chloride; metalworking fluids and preservatives/fragrances as their additives (28.6%); and rubber additives in protective gloves (17.9%) were the main sensitizers. Airborne eczema was diagnosed in 6 (21.4%) metalworkers¹³ (Table 2). One patient working as a foundryman in an ironworking factory had workplace-related recurrent attacks of mercurial Baboon syndrome.¹⁴

3.4 Healthcare workers

Rubber allergens in medical gloves were the main sensitizers (Table 1 and 3). Profession-specific sensitizations were observed with methacrylates in dentists/dental technicians, and thimerosal-containing eye drop in an ophthalmologist, both presenting with fingertip eczema, and with MCI/MI-containing ultrasound gel¹⁵ in a perinatologist. An airborne pattern was observed in 2 healthcare workers (Table 2).

3.5 Miscellaneous

This was a heterogeneous group of occupations (Table 3). In addition to rubber allergens (Figure 2A-C) as the most frequent cause of OACD in this group, profession-specific sensitizers comprised epoxy resin in electricians and shipwright, sesquiterpene lactones in florists, azo dyes in a printer (Figure 2D-F), colophonium in an artistic painter, pine sawdust in a carpenter, and cinnamon in a baker,¹⁶ the latter two presenting with airborne eczema (Table 2).

3.6 Diagnostic patch test series

The relevant allergens were detected by testing with our extended baseline series alone in 73.8% of patients (n=217), with the extended baseline series + other series/patient's own material in 21.8% (n=64), and with other series/patient's own material alone in 4.4% (n=13). The baseline series alone could detect OACD in the majority of construction workers (n=131/133, 98.5%), but only in 30.9% of hairdressers (n=17/55).

4. Discussion

Potassium dichromate was the most frequent occupationally relevant allergen in our series from Turkey, particularly among construction workers. The main relevant occupational products were cement, rubber, hairdressing chemicals, resins/glues/plastics, metals, and preservative-containing products. Recent reports from Finland and Denmark indicated plastics/resins and rubber as the leading group of allergenic products, together with preservative-containing products, metals, and hairdressing chemicals.^{10, 17} In France, metals were the leading group, but the five largest groups of occupational products were the same as in Finland and Denmark.¹⁸ Since the Cement Directive came into force in the EU (Cement Directive 2003/53/EC)¹ and in many other countries, occupational chromate allergy was mainly induced by leather products in these countries¹⁹⁻²¹ so that a similar restriction was set for the hexavalent chromium content in leather articles in Europe in 2015.²²

The high share of concomitant involvement of hands and feet among construction workers was a striking finding as hands and feet are rarely exposed to the same allergen. All of the patients with hand&foot eczema had chromate allergy. In contrast, only half of them had additional thiuram allergy, suggesting that this uncommon site involvement was probably due to the accumulation of chromium in gloves and shoes by repetitive contact with cement, as recently suggested.²³ In countries with the cement regulation, hand&foot eczema was mainly reported in female patients from chromium in leather products.²⁴

Cobalt was the most common source of co-sensitization in chromate-allergic construction workers in our study and in previous reports.²⁵⁻²⁷ The presence of OACD from chromium in cement and thiurams in protective gloves in the same patient was rarely reported among construction workers.²⁸ The very strong association between thiuram and chromate allergy was almost a marker for construction workers in the present study.

Hairdressers were the second most common occupational group in our series. Hairdresser apprentices were almost as frequently sensitized to hairdresser chemicals as professionals in our study, accounting for the young age and early onset of OACD, a well-defined feature for hairdressers²⁹⁻³². As an exception to the literature,³⁰⁻³⁶ male patients predominated among hairdressers in our series because men are more frequently employed as hairdressers in Turkey. Atopics were slightly more frequent among hairdresser apprentices than professionals supporting the so-called “healthy worker effect”, which indicated those who leave their job at an early stage of occupation due to atopy-related morbidity.^{30, 34}

The most common occupational allergens for hairdressers in our study were PPD, toluene-2,5-diamine sulfate (PTD), and other para-group hair dye allergens, and ammonium persulfate in hair bleach, similar to previous reports.^{29, 30, 33, 35, 37-40} Ammonium persulfate was the predominating allergen in some studies.³⁸ Dust containing bleaches are still commonly used in Turkey, leading to a relatively high sensitization rate (49.1%) and airborne ACD from ammonium persulfate in more than half of the patients in our study.

PPD was a very good marker for para-group hair dye allergy as it was positive in all of the patients with a positive patch test reaction to para-group allergens. Hair dyes seemed to be the primary sensitizer as black henna tattoos were present in the history of only a minority. Angioedema-like periorbital oedema as an often misdiagnosed specific pattern of ACD from PPD/hair dyes was present in a higher percentage (20%) of patients than was previously reported.^{33, 41}

Rubber glove and thiuram were the least common occupational allergens for hairdressers in the present and some other studies.^{42, 43} This might be due to the fact that some of the hairdressers did not wear gloves, or only wear gloves for a short period of time, and that they usually prefer cheap polyethylene film gloves, or less frequently the black nitrile gloves.

Metalworkers were the third common occupational group in our study, mainly sensitized with metals and MWF/additives. Lathe operator and jeweller were the main subgroups of metalworkers who were regularly exposed to MWF. The main sensitizing additives in MWF were cocamide diethanolamide, p-tert-butylcatechol, MCI/MI and/or MI, and fragrance in our series. Recent reports, however, indicated monoethanolamine, colophonium/abietic acid, formaldehyde/releasers, and iodopropynyl butylcarbamate as the leading MWF allergens.^{44, 45} MI and MCI/MI, preservatives in water-based MFW such as coolants/cutting fluids, were reported to frequently cause OACD in metalworkers due to the lack of legislative measures for their use in industrial products.⁴⁶⁻⁴⁸ A recent study found that rubber glove allergy was less important for metalworkers,⁴⁵ probably because metalworkers, like hairdressers, usually do not wear protective gloves continuously for a long time, thus limiting their exposure to rubber allergens.⁴⁵

The fourth common profession in our study was healthcare workers. Unlike hairdressers and metalworkers, wearing protective gloves continuously for a long time was the main reason for rubber glove allergy, especially among nurses and medical doctors. Similar to previous reports,^{49, 50} nurses were the main occupational subgroup among healthcare workers. Rubber allergens were reported to cause airborne OACD in nurses,⁵¹ that was the case in our series as well.

Apart from rubber additives, nickel/metals in metal tools, topical medicament/dysinfectants, preservatives (MCI/MI, formaldehyde, thimerosal), and colophonium in adhesive tapes were other relevant allergens for healthcare workers in our series, which was in line with previous reports.^{49, 52-55} In a study from Japan, dysinfectants such as chlorhexidine gluconate and povidone-iodine were the leading causes of OACD in medical doctors.⁵⁶ In contrast to the literature, OACD from systemic drugs,^{57, 58} fragrances/excipients in hand cleansers/dysinfectants,⁵⁹ or MCI/MI in industrial hand cleansers⁴⁶ were not observed in our study, the latter not even during the MCI/MI epidemic in Turkey.¹⁵

Patch testing only with the baseline series was reported to detect a moderate proportion of OACD.⁶⁰ Our extended baseline series alone was sufficient for the diagnosis of OACD in $\frac{3}{4}$ of patients except in hairdressers. Testing with the hairdresser series was necessary, especially not to miss ammonium persulfate allergy. Additional important patch test series were metal series and dental series, the latter including methacrylates for dentists. Patient's own workplace material could identify the culprit in a considerable number of patients comprising metalworkers with OACD from MFWs, healthcare workers with OACD from adhesive tapes and eye drop, and the miscellaneous group with OACD from ultrasound gel, steering wheel cover, wood dust, paper, shoe dye, shoe polish, and elastic bandage. The importance of additional patch testing with specific supplementary series and the patient's own workplace material in revealing the causative allergens was highlighted in previous reports.^{25, 45, 55} A systematic stepwise approach was suggested for the diagnosis of OACD with a special emphasis on occupational allergens not included in the European baseline series.⁶¹

A recent study from Finland showed a clear decrease of occupational skin diseases in 2010, which was attributed to the economic recession after the international financial crisis in 2008.⁶² Comparing the two time periods 1996-2009 and 2010-2019, the total number of patients with OACD decreased significantly in the later period of our study, namely after 2010. The most unexpected decrease was in the number of construction workers, which fell by more than half after 2010, although the cement directive was not yet in force in our country. However, according to the TCMA (personal communication), more and more companies add ferrous sulfate to their cement, and there is an increased use of pre-cast concrete blocks in the construction industry. So, workers come into less contact with bagged cement.

The only significant increase was observed in hairdressers with OACD after 2010 in our series. That was primarily related to an increase in ammonium persulfate allergy, similar to previous reports from Spain and Germany.^{32, 63}

Following the global MCI/MI epidemic, the legal restrictions of the use of isothiazolinones in cosmetic products led to a significant decrease of cosmetics-related OACD in hairdressers in many European countries.⁴⁷ Similarly, no new cases of OACD due to hair gel were diagnosed in our study since 2016, following the ban of MCI/MI and MI in leave-on products in Turkey.¹⁵ OACD from rinse-off cosmetics, on the other hand, continued to exist among hairdressers, probably due to the still high level of MI (100 ppm) in these products in our country.¹⁵ On the contrary, the lack of adequate restrictions on the use of isothiazolinones in industrial products led to an increase in other occupations, particularly house painters, in the post-epidemic period.⁴⁷ Indeed, OACD from MCI/MI and/or MI among house painters, metalworkers, healthcare workers and a house cleaner were all seen after 2015, which was the peak year of the epidemic in Turkey, in our study.

The main limitation of this study was its retrospective design. The use of standardized forms for precise documentation of the clinical features and the patch test findings of each patient allowed us to analyse a large dataset over a long period, and to interpret the causal changes affecting the time-dependent course of relevant occupational sensitizations, which were the strengths of our study.

4 Conclusion

This was the largest series of patients reflecting the epidemiologic profile of OACD in Turkey. The male predominance, even among hairdressers, was striking. Our study highlighted three significant points: First, contact allergy to rubber additives in protective gloves was a common and constant problem in all occupations. Second, despite the surprising decreasing tendency

recently, OACD was most frequently observed among construction workers in our country, where the cement directive is not yet in force. Hand&foot eczema, and co-sensitizations to chrome&thiuram and chrome&cobalt were highly characteristic for OACD in construction workers. Chrome and cobalt were still the most important cement allergens in Turkey. Third, ammonium persulfate allergy was increasing among hairdresser apprentices and professionals. So, we believe that there is a need for future planning of legislative and preventive measures for OACD in Turkey, such as the cement regulation, and easy access to accelerator-free gloves and dust-free hair bleach.

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Tables

Table 1. Characteristics of patients with occupational allergic contact dermatitis (OACD) diagnosed between 1996-2019.

MOAHLFAP: Male-occupational dermatitis-atopic dermatitis/atopic skin-hand dermatitis-leg dermatitis-face dermatitis-age ≥ 40 years-at least one positive patch test reaction to baseline series allergens, NA: not applicable, PPD: p-phenylenediamine, MBT: 2-mercaptobenzothiazole, MCI: methylchloroisothiazolinone, MI: methylisothiazolinone, MDA: 4,4'-diaminodiphenylmethane, PTBP-FR: p-tert-butylphenol formaldehyde resin, MDBGN: methyldibromo glutaronitrile

	Construction worker (n=133)	Hairdresser (n=55)	Metal worker (n=28)	Healthcare worker (n=25)	Miscellaneous (n=53)	Total (n=294)
Demographic features						
Gender, male:female	133:0	35:20	25:3	10:15	40:13	243:51 (4.8:1)
Age, year, range (median)	19-67 (38)	14-50 (23)	18-54 (32)	22-56 (29)	18-59 (38)	14-67 (33)
Age ≥ 40 years	64/133 (48.1%)	5/55 (9.1%)	5/28 (17.9%)	2/25 (8%)	22/53 (41.5%)	98/294 (33.3%)
Atopic skin / atopic dermatitis	4/133 (3%)	6/55 (10.9%)	0/28	0/25	4/53 (7.5%)	14/294 (4.8%)
Onset of OACD, occupational year, range (median)	0.5-38 (8)	0.5-28.5 (2)	0.5-19.5 (4.8)	0.5-29 (2)	0.5-35 (6)	0.5-38 (5.5)
Duration of eczema until the diagnosis of OACD, year, range (median)	0.5-30 (3)	0.5-15 (1)	0.5-15 (1)	0.5-13 (0.5)	0.5-30 (3)	0.5-30 (2)
MOAHLFAP index in %	NA	NA	NA	NA	NA	82.7-100-4.8- 95.6-0.3-21.8- 33.3-95.6
Occupationally relevant contact allergen, n (%)						
Potassium dichromate	124/133 (93.2%)	0/55	7/28 (25%)	1/25 (4%)	4/53 (7.5%)	136/294 (46.3%)
Thiurams	76/133 (57.1%)	2/55 (3.6%)	2/28 (7.1%)	16/25 (64%)	13/53 (24.5%)	109/294 (37.1%)
Cobalt chloride	53/133 (39.8%)	0/55	6/28 (21.4%)	2/25 (8%)	4/53 (7.5%)	65/294 (22.1%)
Zinc diethyldithiocarbamate	44/133 (33.1%)	1/55 (1.8%)	2/28 (7.1%)	8/25 (32%)	7/53 (13.2%)	62/294 (21.1%)
PPD/para-group hair dyes	0/133	46/55 (83.6%)	0/28	0/25	3/53 (5.7%)	49/294 (16.7%)
Ammonium persulfate	0/133	27/55 (49.1%)	0/28	0/25	0/53	27/294 (9.2%)

Mercaptos / MBT	16/133 (12%)	1/55 (1.8%)	2/28 (7.1%)	2/25 (8%)	4/53 (7.5%)	25/294 (8.5%)
Nickel sulfate	8/133 (6%)	0/55	8/28 (28.6%)	2/25 (8%)	4/53 (7.5%)	22/294 (7.5%)
Colophonium	5/133 (3.8%)	0/55	0/28	2/25 (8%)	9/53 (16.9%)	16/294 (5.4%)
MCI/MI and/or MI	5/133 (3.8%)	6/55 (10.9%)	2/28 (7.1%)	1/25 (4%)	1/53 (1.9%)	15/294 (5.1%)
Epoxy resin / epoxy chemicals	3/133 (2.3%)	0/55	2/28 (7.1%)	0/25	9/53 (16.9%)	14/294 (4.8%)
Fragrances	0/133	2/55 (3.6%)	1/28 (3.6%)	0/25	5/53 (9.4%)	8/294 (2.7%)
Coexisting allergens / localizations, n (%)						
Chromium&thiuram	72/133 (54.1%)	0/55	1/28 (3.6%)	0/25	1/53 (1.9%)	74/294 (25.2%)
Chromium&cobalt	53/133 (39.8%)	0/55	3/28 (10.7%)	1/25 (4%)	3/53 (5.7%)	60/294 (20.4%)
Hand&foot	25/133 (18.8%)	0/55	0/28	0/25	3/53 (5.7%)	28/294 (9.5%)
Occupationally relevant products, n (%)						
Cement	124/133 (93.2%)	0/55	0/28	0/25	0/53	124/294 (42.2%)
Rubber glove	83/133 (62.4%)	4/55 (7.3%)	5/28 (17.9%)	16/25 (64%)	14/53 (26.4%)	122/294 (41.5%)
Hairdressing chemicals	0/133	49/55 (89.1%)	0/28	0/25	0/53	49/294 (16.7%)
Resins/glues/plastics (containing epoxy/ acrylates/isocyanates/MDA/ colophonium/PTBP-FR)	8/133 (6%)	0/55	4/28 (14.3%)	4/25 (16%)	22/53 (41.5%)	38/294 (12.9%)
Metals / metal tools	8/133 (6%)	0/55	18/28 (64.3%)	3/25 (12%)	4/53 (7.5%)	33/294 (11.2%)
Preservative-containing products	5/133 (3.8%)	8/55 (14.5%)	2/28 (7.1%)	2/25 (8%)	2/53 (3.8%)	19/294 (6.5%)
Perfumed products	0/133	2/55 (3.6%)	1/28 (3.6%)	0/25	5/53 (9.4%)	8/294 (2.7%)

Table 2. The relevant contact allergens in patients with airborne occupational allergic contact dermatitis (n=63) diagnosed between 1996-2019.

Relevant occupational allergen (No. patients)	Relevant occupational product (No. patients)	Relevant occupation (No. patients)
Potassium dichromate (15)	Cement (15)	House builder/bricklayer (15)
Ammonium persulfate (14)	Hair bleach (14)	Hairdresser (14)
Epoxy resin (12)	Adhesive / glues (4)	Floor layer (1), jewellery designer (1), leather worker (1), draughtsman (1)
	Shipyards paints (3)	Shipwright (3)
	Epoxy chemicals (3)	Aircraft mechanics (2), paint fabric worker (1)
	Wall paint (2)	House painter (2)
MCI/MI and MI (6)	Water-based wall paints (5)	House painter (5)
	Rust remover spray (1)	Tramline worker ¹³ (1)
Thiurams (4)	Rubber glove (4)	Nurse (1), house cleaner (1), cook (1)
Sesquiterpene lactone mix (4)	Chrysanthemum flower (4)	Florist/gardener (4)
Colophonium (3)	Adhesive / glues (2)	Billposter (1), bookbinder (1)
	Pine sawdust (1)	Carpenter (1)
Cobalt / nickel (3)	Metal dust / vapour (3)	Metal factory worker (1), jeweller (1), dentist (1)
Coconutdiethanolamine (1)	Cooling fluid (1)	Jeweller (1)
p-aminoazobenzene (1)	Printing ink (1)	Printer (1)
Cinnamon / cinnamic alcohol (1)	Bakery products (1)	Baker ¹⁶ (1)

Table 3. The main relevant occupational products in different occupational subgroups with occupational allergic contact dermatitis. The total number of the products is greater than the number of patients, as patients were usually sensitized with more than one occupational product.

MWF: metalworking fluids, PTBP-FR: 4-tert-Butylphenolformaldehyde resin

Occupational subgroups (No. patients)	ISCO-08 Codes	Main relevant occupational product (No. patients)
Construction workers (133)		
House builders/bricklayers (120)	7111/7112	Cement (116), nitrile coated cotton glove/rubber glove (81)
Construction painters (8)	7131	Wall paint (8), cement (3), rubber glove (2)
Floor layers / tile setters (5)	7122	Cement only (5), rubber glove (2), epoxy adhesive (1)
Hairdressers (55)		
Women's hairdressers (50)	5141.02	Hair dye (45), hair bleach (28), rubber glove (5), shampoo (4), permanent wave (2), hair cosmetics (1)
Men's barbers (5)	5141.01	Hair gel/wax (4), hair dye (1), shampoo (1)
Metal workers (28)		
Worker in metal factory/blacksmith (10)	7221	Metal (9), MWF/additives (1), rubber glove (1)
Lathe operator (6)	7223	Metal (4), rubber glove (3), MWF/additives (3)
Mechanics (6)	7231, 7232	Metal (2), adhesives/epoxy chemistries (2), black rubber (1), MWF/additives (1), rust remover ¹³ (1)
Jeweller (5)	7313	Metal (3), MWF/additives (3), rubber glove (1)
Miner (1)	7111	Metal (1)
Healthcare worker (25)		
Nurses (10)	2221	Rubber glove (8), antiseptics/dysinfectants (2), adhesive medical tapes (2), face mask (1)
Medical doctors (8)	2212	Rubber glove (6), antiseptics/dysinfectants (1), thimerosal-containing eye drop (1), ultrasound gel ¹⁵ (1)
Dentists/dental technicians (4)	2261/3214	Acrylates (2), mercury/amalgam (1), nickel vapour and hydroquinone-containing film developer (1)
Healthcare assistants (2)	5321	Rubber glove (2), antiseptics/dysinfectants (2)
Hospital cleaner (1)	9112	Metal tools (1)
Miscellaneous (53)		
House cleaner (6)	9111	Rubber glove (5), cleaning products (2)
Electrician (5)	7411	Black rubber (2), epoxy-containing insulation material (1), plastic (1), metal (1)
Food worker (cook / baker / grocer) (5)	5120 / 7512 / 5221	Rubber glove (3), cinnamon ¹⁶ (1), food additives (1)

Shoemaker (4)	7536	Rubber (1), shoe polish (1), shoe dye (2)
Furniture maker (3) / carpenter (1)	7522 / 7115	Isocyanate-containing furniture polish (1), epoxy glue (1), metals (1) / pine sawdust (1)
Florist (3) / gardener (1)	7549 / 6113	Chrysanthemum flower (4), laurel (2), rubber glove (1) / metal tools (1)
Shipwright (3)	7214 and 7131	Epoxy-containing paints (3), pine tar (1)
Driver (3)	8322	Steering wheel cover (3)
Textile worker (3)	7533 and 8153	Metal tools (2), colophonium-containing glue + fabric finisher (2), rubber glove (1)
Printer (2) / bookbinder (1)	7322 / 7323	Paper + colophonium-containing glue (1), printing ink (1) / colophonium-containing glue (1)
Architect (1) / draughtsman (1) / artistic painter (1)	2161 / 3118 / 2651	PTBP-FR-containing glue (1) / epoxy glue + paper (1) / paper + ink (1)
Leather worker (2)	7535	Epoxy adhesives (1), chrome-tanned leather (1)
Jewellery designer (2)	2163	Epoxy glue (1), modelling wax (1)
Paint fabric worker (1)	8131	Rubber glove + epoxy-containing paints (1)
Rubber worker (1)	8141	Black rubber (1)
Office worker (1)	4110	Rubber band (1)
Dairyman (1)	6121	Rubber hose (1)
Basketball player (1)	3421	Self-adhesive ankle protection bandage (1)
Billposter (1)	9629	Colophonium-containing glue (1)

Legends for Figures

Figure 1. (A) Occupational allergic contact dermatitis on hands and feet of a cement worker, (B) +++ positive patch test reaction to potassium dichromate (0.5% pet.) and thiuram mix (1% pet.) on day 2, (C) + positive patch test reactions to a piece of nitrile coated glove (moistened with water, tested for 72 hours), and negative patch test reaction to a piece of the cotton part of the nitrile coated glove (moistened with water, tested for 72 hours) on day 3.

Figure 2. (A, B, C) OACD on hands of an electrician from N-isopropyl-N-phenyl-4-phenylenediamine in black rubber, (D, E, F) OACD on hands of a printer showing positive patch test reactions to 4-amino azobenzene (0.25% pet.) and pieces of printed paper (moistened with water, tested for 72 hours) on day 3.



