

Occupational contact allergy in nurses: results from the Information Network of Departments of Dermatology 2003–2012

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Summary

Background. Healthcare workers are occupationally exposed to various allergens in protective gloves, surface or instrument disinfectants, drugs, and skin care products. An increased prevalence of sensitization to thiurams, glutaraldehyde, formaldehyde and glyoxal in nurses with occupational contact dermatitis (OCD) has been known since the 1990s.

Objectives. To update the range of occupational allergens in healthcare professionals.

Methods. We retrospectively analysed patch test data from the Information Network of Departments of Dermatology (IVDK), 2003–2012. Patch test results from 2248 nurses with OCD were compared with those of 2138 nurses without OCD.

Results. 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, for example tetrazepam.

Conclusions. The known range of contact sensitization in nurses with OCD has been confirmed. Formaldehyde allergy seems to be less important today. Drugs such as tetrazepam are occupational sensitizers in nurses. The increase in chromium sensitization remains unexplained.

Key words: contact allergy; formaldehyde; healthcare workers; nurses; occupational; occupational skin disease; thiuram mix.

Occupational contact dermatitis (OCD) is very frequent among nurses and other healthcare workers, with an estimated prevalence of up to 30% (1, 2). The most common clinical presentations are chronic irritant and/or allergic contact dermatitis, or airborne contact dermatitis (2).

Irritant contact dermatitis mostly results from frequent hand washing, wet work, wearing of occlusive gloves, and, to a lesser extent, the use of hand disinfectants (3). Allergic contact dermatitis in the healthcare sector mainly arises from contact with rubber constituents of protective gloves, active ingredients of surface and instrument disinfectants, drugs for systemic or topical application, or components of skin care products such as emollients, barrier creams, or liquid soaps (1, 2).

Analysis of data from the Information Network of Departments of Dermatology (IVDK) between 1992 and 1995 showed an increased prevalence of sensitization to thimerosal, thiurams, glutaraldehyde, formaldehyde and glyoxal in nurses with occupational skin disease (1). Since

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Table 1. MOAHLEA index of the study group [nurses with occupational contact dermatitis (OCD); n = 2248] and the control group (nurses without OCD; n = 2138)

	Nurses with OCD		Nurses without OCD	
	n	% (95% CI)	n	% (95% CI)
Male (M)	262	11.7 (10.4–13.1)	171	8.0 (6.9–9.2)
Occupational dermatitis (O)	2248	100*	0	0*
Atopic dermatitis (A)	869	38.7 (36.6–40.7)	443	20.7 (19.0–22.5)
Hand dermatitis (H)	1683	74.9 (73.0–76.6)	402	18.8 (17.2–20.5)
Leg dermatitis (L)	24	1.1 (0.7–1.6)	113	5.3 (4.4–6.3)
Face dermatitis (F)	167	7.4 (6.4–8.6)	490	22.9 (21.2–24.8)
Age ≥ 40 years (A)	1206	53.6 (51.6–55.7)	1357	63.5 (61.4–65.5)

CI, confidence interval.

*100% and 0%, respectively, by group definition; therefore, no 95% CI calculated.

2002, the German Contact Dermatitis Research Group (DKG) has recommended patch testing with the baseline series, disinfectant series, rubber series and preservative and ointment base series in nurses with suspected allergic OCD (2, 4).

With the aim of updating the spectrum of occupational allergens in healthcare professions and to determine whether the prevailing recommendations should be adjusted, we analysed recent IVDK data from the years 2003 to 2012.

Patients and Methods

This retrospective analysis was based on data of the IVDK, dedicated to the clinical epidemiology of contact allergy. Currently, 56 departments of dermatology in Germany, Switzerland and Austria are IVDK members. The structure and routine operating procedure of the network are described elsewhere in detail (5). In brief, anonymized medical history and clinical data, as well as test results, of all patients patch tested in the participating hospitals are sent to the IVDK central office at the University of Göttingen twice a year. Data are subject to standardized quality control and analysed according to international standards (6, 7).

For this data analysis, we selected patients with OCD patch tested between 2003 and 2012 with the following current or previous professions: nurse, theatre nurse, doctor's assistant, nurse assistant, ambulance crew, or midwife. There were 2248 patients. OCD was defined as work-related skin lesions resulting from either irritant or allergic contact dermatitis, or triggering of a constitutional predisposition (e.g. atopic dermatitis). A control group consisted of 2138 dermatitis patients from the same professions, but without OCD. Geriatric nurses were excluded from this analysis, because it is known that their occupational allergen spectrum differs from that of other nurses (8, 9).

Patch tests were performed and read according to international guidelines, revised by the DKG (10). Evaluation of the patch test results was based on the reactions seen at D3. In a few exceptional cases, when a reading was performed at D4 instead, this reaction was selected. Patch test reactions were regarded as positive if they were characterized by erythema plus infiltration, papules, and/or vesicles (+, ++, or +++). Age and sex standardization of reaction frequencies was performed according to published methods (11, 12) and supplemented with exact 95% confidence intervals (CIs). Statistically significant differences at a 5% level were concluded from non-overlapping 95% CIs when separate subgroups were compared. Data analysis was performed in the IVDK central office at the University of Göttingen, with the SAS® 9.3 program package (SAS Institute, Cary, NC, USA).

Results

In the time period of this data analysis (2003–2012), 108 198 patients were patch tested in the departments of dermatology forming the IVDK. The study group (n = 2248) represents 2.1% of all tested patients and the control group (n = 2138) 2.0%.

A description of both the study group and the control group, according to the MOAHLEA index, is given in Table 1. As expected, far more patients with hand dermatitis were found in the study group (75% versus 19%), as were, consequently, fewer patients with leg or face dermatitis. Patients in the study group were younger, and among them were more patients with a history of atopic dermatitis (39% versus 21%). Although women predominated in both groups, slightly more men were found in the study group than in the control group (12% versus 8%). All differences were statistically significant. The age distribution in both patient groups is shown in Fig. 1. A peak in the third decade was found in the study group. It

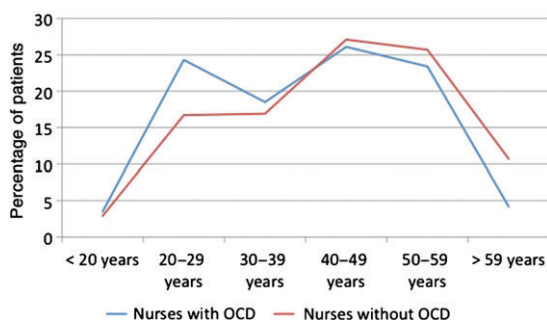


Fig. 1. Age distribution in the study group (blue line) and the control group (red line). See text for details. OCD, occupational contact dermatitis.

is notable that only 67 patients (3%) in the study group had generalized eczema, as compared with 302 (14%) of the control group patients. In both groups, the largest professional groups were nurses [1572 patients (70%) of the study group; 1406 patients (66%) of the control group], followed by doctor's assistants [$n = 224$ (10%) in the study group, $n = 393$ (18%) in the control group].

The DKG baseline series was tested in 2083 patients (93%) of the study group, the DKG disinfectant, ointment base and preservative series in ~1750 patients (78%), and the DKG rubber series in 1498 patients (67%). The absence of testing with one series or another was attributable to previous patch testing outside the IVDK or aspects of the patients' individual history. Table 2 shows the frequency of reactions to allergens eliciting positive reactions in > 1% of the total study population. Besides allergens from the baseline series, this spectrum contains povidone iodine, thiurams, thimerosal, glutaraldehyde, glyoxal, some ointment bases, some fragrances, and some preservatives. Remarkably, mercaptobenzothiazole (MBT) or one of its derivatives was not among these 40 most frequent allergens. The same applied for dithiocarbamates other than zinc diethyldithiocarbamate and thioureas. We did not analyse reactions to these rubber chemicals in detail, because this has just recently been performed (13). Benzalkonium chloride, the only representative of quaternary ammonium compounds, which is contained in surface and instrument disinfectants, elicited positive reactions in only 20 of 1782 patients (1.1%). Among the aldehydes, glutaraldehyde was the most frequent sensitizer ($n = 68$ positive patients), followed by formaldehyde ($n = 48$), and glyoxal ($n = 36$). All of these compounds were patch tested in parallel in 1618 patients. Concomitant reactions are shown in Fig. 2. Approximately half of the patients reacting to formaldehyde or glyoxal also reacted to another aldehyde, whereas with glutaraldehyde this proportion was only 29% (18 of 62 patients).

The DKG baseline series was also tested in 1917 patients (90%) of the control group. Hence, concerning patch test results with allergens from the baseline series, no selection bias is introduced by more or less strict indications for testing. Therefore, a comparison of reaction frequencies in the study group and in the control group makes sense. This does not apply to the other special series mentioned above, which were tested in far lower proportions of control group patients than in the study group. For this comparison, age-standardized and sex-standardized frequencies of sensitization have to be used in order to eliminate a bias introduced by different proportions of men and women, and younger and older people. Table 3 gives an overview of those baseline series allergens eliciting positive reactions in > 1% of the study group. Significant differences in reaction frequencies between the study group and the control group (identifiable from non-overlapping 95% CIs) were found for thiuram mix (6.7% in the study group versus 1.2% in the control group), potassium dichromate (5.7% versus 3.2%), methylchloroisothiazolinone (MCI)/methylisothiazolinone (MI) (4.4% versus 1.8%), colophonium (3.4% versus 1.9%), 2-bromo-2-nitropropane-1,3-diol (bronopol; 1.7% versus 0.5%), and zinc diethyldithiocarbamate (ZDEC) (1.7% versus 0.1%). In addition, the age-standardized and sex-standardized frequency of positive reactions to methyltribromo glutaronitrile was increased (4.2% versus 1.6%). However, there was a borderline overlap of the 95% CIs.

Not all potential occupational allergens are covered by commercially available patch test series. Therefore, patch testing with products from the patients' workplaces is mandatory. In our study group, this was performed in 1057 patients with 7828 single patch tests. We assigned the test material to different categories, and analysed the respective patch test reactions. The results are summarized in Table 4. Of 44 patients reacting to their own gloves, 21 also reacted to thiurams, 5 to ZDEC, and 2 each to 1,3-diphenylguanidine and MBT derivatives. Hand disinfectants elicited positive reactions in 30 of 556 patients tested. The test concentration varied from 1% aq (131 patch tests) and 10% aqua ($n = 299$) to 100% ($n = 680$). With a test concentration of 100%, 22 positive test reactions (20 +; 2 ++) were seen, with 8 positive reactions (+) to 10% aqua, and 4 positive reactions (all +) to 1% aq. Pure alcohols were tested less frequently. Ethanol 70% or 80% aq was tested in 11 patients, with negative results throughout. Propanol and isopropanol were tested at 1%, 10% and 70% aq in 5 patients (six tests), also with negative results. Concerning surface and instrument disinfection, the variety of test concentrations was even

Table 2. Information Network of Departments of Dermatology, 2003–2012, nurses with occupational contact dermatitis: frequency of sensitization to allergens that elicited positive patch test reactions in > 1% of the study group, that is, 22 patients

Allergen	Number of patients tested	Number of patients with positive reactions	Percentage of positive patients (95% CI)
Nickel sulfate	1964	478	24.3 (22.5–26.3)
Fragrance mix I	2007	205	10.2 (8.9–11.6)
Cobalt chloride	2019	175	8.7 (7.5–10.0)
Thiuram mix	2026	157	7.7 (6.6–9.0)
Povidone iodine	1723	150	8.7 (7.4–10.1)
Balsam of Peru (<i>Myroxylon pereirae</i>)	2048	145	7.1 (6.0–8.3)
Fragrance mix II	1625	121	7.4 (6.2–8.8)
Potassium dichromate	2044	115	5.6 (4.7–6.7)
Tetraethylthiuram disulfide	1473	107	7.3 (6.0–8.7)
Methylchloroisothiazolinone/ methylisothiazolinone	2048	103	5.0 (4.1–6.1)
Hydroxyisohexyl 3-cyclohexene carboxaldehyde	2043	93	4.6 (3.7–5.5)
Colophonium	2046	80	3.9 (3.1–4.8)
Methyldibromo glutaronitrile	1680	79	4.7 (3.7–5.8)
Glutaraldehyde	1796	68	3.8 (3.0–4.8)
Tetramethylthiuram monosulfide	1477	68	4.6 (3.6–5.8)
Tetramethylthiuram disulfide	1476	56	3.8 (2.9–4.9)
Propolis	2050	49	2.4 (1.8–3.1)
Formaldehyde	2047	48	2.3 (1.7–3.1)
Thimerosal	235	48	20.4 (15.5–26.2)
Amerchol® L 101	1728	47	2.7 (2.0–3.6)
Dipentamethylene thiuramdisulfide	1477	44	3.0 (2.2–4.0)
Lanolin	2058	44	2.1 (1.6–2.9)
Methylisothiazolinone	1025	44	4.3 (3.1–5.7)
Cocamidopropyl betaine	1723	41	2.4 (1.7–3.2)
2-Bromo-2-nitropropane-1,3-diol	1984	39	2.0 (1.4–2.7)
Oil of turpentine	2046	36	1.8 (1.2–2.4)
tert-Butyl hydroquinone	1733	36	2.1 (1.5–2.9)
Glyoxal	1725	36	2.1 (1.5–2.9)
Zinc diethyldithiocarbamate	2031	35	1.7 (1.2–2.4)
Propylene glycol	1727	33	1.9 (1.3–2.7)
Isoeugenol	621	32	5.2 (3.6–7.2)
Iodopropynyl butylcarbamate	1697	32	1.9 (1.3–2.7)
Oakmoss absolute (<i>Evernia prunastri</i>)	607	32	5.3 (3.6–7.4)
1,3-Diphenyl guanidine	1509	30	2.0 (1.3–2.8)
Octyl gallate	1718	30	1.7 (1.2–2.5)
Quaternium-15	1735	28	1.6 (1.1–2.3)
Hydroxycitronellal	607	26	4.3 (2.8–6.2)
Mercury ammonium chloride	593	24	4.0 (2.6–6.0)
Tree moss (<i>Evernia furfuracea</i>)	319	23	7.2 (4.6–10.6)
Ylang-ylang (I + II) oil	917	23	2.5 (1.6–3.7)

CI, confidence interval.

broader, ranging from 10 ppm (0.001%; 17 patch tests) to 50% aq (two tests; surprisingly negative). The most frequently used test concentrations were 100 ppm (0.01%; 122 tests), 0.1% aq (251 tests), 1% aq (257 tests), and 10% aq (63 tests). Altogether, 43 positive reactions were

noted, namely: 3 + reactions to 10 ppm; 2 + reactions to 100 ppm; 1 + reaction to 0.05% aq; 8 +, 3 ++ and 3 +++ reactions to 0.1% aq; 11 +, 5 ++ and 5 +++ reactions to 1% aq; and 2 + reactions to 10% aq. Irritant and doubtful reactions were numerous among all

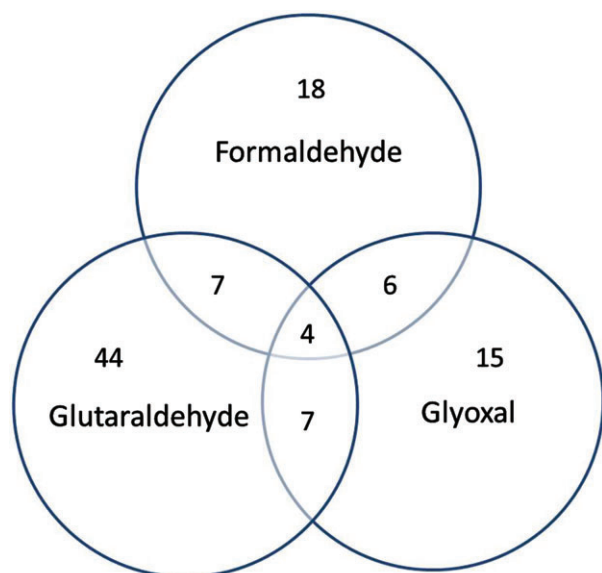


Fig. 2. Venn diagram of concomitant reactions to formaldehyde, glutaraldehyde, and glyoxal.

test concentrations. Single components of surface or instrument disinfection preparations were tested in only a very few cases. In 4 patients, dodecyl dipropylenetriamine was tested at a concentration of 100 ppm aqua, eliciting 1 irritant reaction and 3 negative reactions. It is possible, but not certain, that this compound is identical to laurylamine dipropylenediamine. Didecylmethyl ammonium chloride was patch tested at 100 ppm aq in 3 patients, with negative results throughout. Additional higher concentrations were tested in 1 patient, who had a + reaction to 0.05% aq, and an irritant reaction to 0.1% aq. Of 78 patients patch tested with systemic drugs, 36 were tested with tetrazepam (pure). Of these, 1 patient had ++ and +++ reactions, and 2 patients had + reactions. In addition, 2 doubtful reactions were noted.

Discussion

The results of our study show that the spectrum of occupational sensitization in nurses and related healthcare professions is largely unchanged as compared with previous reports (1). The most important contact allergens are rubber chemicals in protective gloves (mainly thiurams, and less frequently dithiocarbamates) and components of surface or instrument disinfectants (glutaraldehyde and glyoxal). One of the major limitations of our study is that we cannot tell to what extent the positive test reactions in our patients with OCD reflect current or past exposures,

Table 3. Age-standardized and sex-standardized reaction frequencies for the 17 most frequently reacting allergens from the German Contact Dermatitis Research Group baseline series in the study group (n = 2248) and the control group (n = 2138)

Allergen	Nurses with OCD, age-standardized and sex-standardized % positive (95% CI)	Nurses without OCD, age-standardized and sex-standardized % positive (95% CI)
Nickel sulfate	19.5 (17.8–21.3)	19.4 (17.4–21.4)
Fragrance mix I	9.4 (7.9–10.8)	7.3 (5.8–8.9)
Cobalt chloride	7.2 (6.0–8.3)	7.3 (5.7–8.9)
Thiuram mix	6.7 (5.5–7.9)	1.2 (0.6–1.9)
Balsam of Peru (<i>Myroxylon perei</i>)	7.0 (5.6–8.3)	7.0 (5.4–8.6)
Fragrance mix II	6.6 (5.2–7.9)	4.3 (2.9–5.6)
Potassium dichromate	5.7 (4.4–7.0)	3.2 (2.0–4.3)
Methylchloroisothiazolinone/methylisothiazolinone	4.4 (3.4–5.3)	1.8 (1.1–2.6)
Hydroxyisohexyl 3-cyclohexene carboxaldehyde	4.1 (3.1–5.1)	2.7 (1.8–3.6)
Colophonium	3.4 (2.5–4.3)	1.9 (1.4–2.4)
Methyldibromo glutaronitrile	4.2 (3.2–5.2)	1.6 (0.9–3.2)
Propolis	2.0 (1.4–2.6)	2.1 (1.2–2.9)
Formaldehyde	1.8 (1.3–2.3)	1.4 (0.7–2.1)
Lanolin alcohols	1.8 (1.2–2.5)	2.6 (1.4–3.8)
2-Bromo-2-nitropropane-1,3-diol	1.7 (1.1–2.3)	0.5 (0.3–0.8)
Oil of turpentine	1.7 (1.0–2.5)	1.2 (0.6–1.8)
Zinc diethyldithiocarbamate	1.7 (1.0–2.3)	0.1 (0.0–0.2)

CI, confidence interval; OCD, occupational contact dermatitis. Allergens with significantly increased sensitization rates among healthcare professionals with OCD are highlighted in bold.

because our data on the patients' individual exposure is limited. This fact also hampers evaluation of the clinical relevance of each sensitization.

Although most of the European manufacturers now avoid thiurams in medical glove production, and prefer dithiocarbamates instead, thiurams still are the most frequent rubber allergens in healthcare workers (13). According to unconfirmed information from European glove manufacturers, thiurams are still widespread in the production of cheap latex or nitrile gloves outside Europe. As hospital operators are under economic pressure, such products are frequently used in many hospitals. Therefore, one might speculate that this exposure maintains the high frequency of thiuram sensitization in nurses. However, our data analysis partly dates back to a time when thiurams were generally the most common accelerators in medical protective gloves. Therefore, many of the thiuram reactions are

Table 4. Information Network of Departments of Dermatology, 2003–2012, nurses with occupational contact dermatitis: patch tests with products from the patients' workplaces

Category	Test concentrations	Number of patients tested	Patients with ≥ 1 positive reactions		Number of patch tests	Positive patch tests	
			n	%		n	%
Protective gloves	As is	599	44	7.3	2468	94	3.8
Workwear, face masks, etc.	As is	115	2	1.7	470	2	0.4
Hand disinfection	1–100%	556	30	5.4	1177	34	2.9
Surface and instrument disinfection	10 ppm to 50%	255	22	8.6	793	43	5.4
Cleaning agents, dish detergents	0.1–10%	78	4	5.1	198	4	2.0
Liquid soap, soap, shower gel, shampoo	0.1–10%	429	25	5.8	1110	39	3.5
Skin protection creams, hand creams	As is	266	6	2.3	517	7	1.4
Skin disinfection*	1–100%	196	9	4.6	376	10	2.7
Drugs for external use, eye drops	As is	140	7	5.0	312	9	2.9
Drugs for internal use (systemic drugs)	As is	78	11	14.1	407	22	5.4

*Products for disinfection of wounds or of the skin prior to puncture, surgery etc., containing, for example, povidone iodine, octenidine, propanol, or biphenyl-2-ol.

certainly of past clinical relevance. Owing to their close chemical relationship, immunological cross-reactions between thiurams and dithiocarbamates are probable (13), in particular in the light of the chemical changes that rubber accelerators undergo during vulcanization (14).

In contrast, sensitization to mercaptobenzothiazole derivatives and thioureas, which are rarely used in medical glove production, was far less frequent in our study group.

Today, aldehydes, quaternary ammonium compounds and amines are the most commonly used active agents in surface and instrument disinfection. In contrast to previous reports (1), it seems that formaldehyde has lost its particular importance in the healthcare sector. We did not observe an increased frequency of sensitization to formaldehyde among nurses with OCD. Concomitant reactions to the aldehydes formaldehyde, glutaraldehyde and glyoxal did occur (Fig. 2), with glutaraldehyde being the most frequent singular sensitizer among them. From clinical data and animal studies, it was concluded in the past that there might be immunological cross-reactivity between these aldehydes (15–17). However, healthcare workers with OCD are or have been very probably exposed to all of them in the course of time, rendering multiple sensitizations a more probable alternative explanation for concomitant reactions. Benzalkonium chloride is the only quaternary ammonium compound that is commercially

available for patch testing. It is a well-known irritant, and probably a very rare allergen (18). Our results confirm that it is not a common sensitizer in healthcare workers. Recent case reports indicate that another quaternary ammonium compound, didecylmethyl ammonium chloride, may be of more importance (19). However, it is rarely patch tested, as can be seen in our data. The same applies for laurylamine dipropylenediamine (20). Our data illustrate that current recommendations for patch testing of surface and instrument disinfectants at concentrations of 0.01%, 0.1% and 1% aq (21) are adequate and useful.

Hand disinfectants are often suspected to be sources of hand dermatitis and contact sensitization, especially in healthcare workers (22). In our data, 5.4% of patients tested with their own hand disinfectant had a positive reaction. However, most of these reactions were weak (+) and were elicited with pure disinfectant, which may be irritating when patch tested in a closed system (20). Hence, without having patch tested single ingredients of the respective product, it is hard to tell whether these reactions are true allergic ones. However, breakdown tests are rarely performed in clinical practice, and the main ingredients of hand disinfectants (i.e. alcohols) are only tested in a very few cases. Garcia-Gavin et al. recently reported contact sensitization to isopropanol, and suspected it of being a missed but important allergen. This issue was a matter of controversy (23–25). Perhaps increased patch

testing of alcohols in nurses with OCD will further elucidate this point.

Nurses and other healthcare workers are frequently exposed to the ingredients of drugs for systemic or topical application. Among the systemic drugs, tetrazepam seems to pose a special risk for contact sensitization, as recent reports have shown (26–28). This substance is frequently given to elderly patients as a sedative. Healthcare professionals are exposed to tetrazepam dust by crushing pills. This can lead to the development of airborne contact dermatitis (26–28). Protective measures such as crushing devices (closed system) should be used for prevention. The small numbers of patients with positive reactions to tetrazepam in our study are likely to represent an underestimate, as elderly care nurses were excluded from our data analysis.

Previously reported positive test reactions to thimerosal in healthcare professionals probably arise from former vaccinations, and are not clinically relevant in most cases (1, 2). Thimerosal was eliminated from the DKG baseline series in 2002.

We found an elevated sensitization rate for MCI/MI in nurses with OCD as compared with the individuals from the same professional category but not affected by a job-related skin disease. This may be related to the more frequent exposure of the former to skin care products such as hand or barrier creams and liquid soaps (2).

Interestingly, in our study group (nurses/health care workers with OCD), sensitization rates for colophony and potassium dichromate were significantly elevated. Sensitization to colophonium might derive from contact with adhesive plasters, bandages, or hydrocolloid dressings (2). Currently, the most frequent general allergen source for sensitization to chromium, in particular among women, is chrome-tanned leather (16). However, a deeper data analysis of our study group gave no clue in this direction (details not shown). This shows the limitations of our study and the approach of clinical epidemiology, as mentioned above. We have no detailed information about the patients' full current or past occupational and private exposure, and hence we cannot state the clinical relevance of these findings. For potassium dichromate in particular, false-positive, irritant reactions also have to be considered.

Among the most frequent allergens reported in nurses with OCD, one can find several 'problematic' test preparations (29, 30) that frequently elicit doubtful, irritant and/or weak positive patch test reactions, for example povidone iodine 10% aqua, glutaraldehyde 0.3% pet., Amerchol® L101 50% pet., propylene glycol 20% aq., 1,3-diphenyl guanidine 1% pet., and octyl gallate 0.3% pet. Although positive test reactions and occupational

exposure may seem to fit together in these cases, a thorough evaluation of the true clinical relevance is mandatory.

Conclusion

The occupational allergen spectrum in healthcare workers is unchanged, and mainly includes ingredients of rubber gloves (thiurams and dithiocarbamates), surface or instrument disinfectants (aldehydes and quaternary ammonium compounds), and skin care products. Developing patch test preparations for currently used quaternary ammonium compounds and amines would be desirable.

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