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Contact Dermatitis and Allergy

Occupational skin disease in the construction industry

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Summary

Background Construction workers have a substantial risk of developing irritant and/or allergic contact dermatitis. Unfortunately, however, there is little population-based epidemiological data relating to occupational skin diseases (OSD) in the European construction industry that allow assessment of preventive measures.

Objectives In this investigation, the yearly incidence rates and causes of OSD in the construction industry were analysed on the basis of our register in Northern Bavaria.

Methods From 1990 until 1999, all incidences of OSD in the construction industry were recorded prospectively. This enables the calculation of incidence rates of OSD in relation to the employed population in Northern Bavaria as recorded by the German Federal Employment Office.

Results In the construction industry, a total of 335 OSD were registered. These comprise 9.0% of all OSD in the register. We classified them into four relevant groups: (A) tile setters and terrazzo workers (incidence per 10 000 employees = 19.9); (B) painters (7.8); (C) construction and cement workers (5.2); and (D) wood processors (2.6). The overall incidence was 5.1 per 10 000 employees over 10 years, which is a little below average for the entire register (6.7). Of these, 43.6% were at least 40 years old. Allergic contact dermatitis (61.5%) occurred more often than irritant contact dermatitis (44.5%). Potassium dichromate caused roughly half of all cases of sensitization found to be occupationally relevant in the construction industry (152 cases) followed by epoxy resin (40) and cobalt chloride (32).

Conclusions The results indicate that potassium dichromate is still the most important allergen in the construction industry of Northern Bavaria; there has been no significant decline during the 1990s. This contrasts with the Scandinavian countries, where the prevalence of potassium dichromate sensitization declined following the reduction of chromium VI levels resulting from the addition of ferrous sulphate to cement. Within the construction industry, tile setters and terrazzo workers have a strikingly high incidence of OSD.

Key words: chromate, construction industry, construction workers, contact dermatitis, ferrous sulphate, skin disease

In Germany, the number of cases and costs of occupational skin diseases (OSD) in the construction industry are increasing.¹ Unfortunately, however, there is little population-based epidemiological data relating to incidences of OSD with regard to demographic characteristics, causes and risk factors that also enable assessment of preventive measures.

Construction workers have a substantial risk of developing irritant (ICD) or allergic contact dermatitis (ACD), which is caused particularly by cement with its main allergen potassium dichromate.^{2–4} In Scandinavian countries, the prevalence of potassium dichromate sensitization has been decreasing since the addition of ferrous sulphate to cement.^{5,6} Some authors report that this is a general trend even in countries that have not reduced the content of soluble potassium dichromate. In this paper we present prospective data on OSD

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among construction workers in Northern Bavaria from 1990 to 1999 and compare them with data already published.

Patients and methods

Since 1990, a register for OSD in Northern Bavaria has existed through the cooperation of the Department of Dermatology at the University of Erlangen and the Bavarian Health and Safety Executive, Department of Occupational Medicine at Nuremberg. The Berufskrankheitenregister Haut-Nordbayern (BKH-N) is a prospective register with standardized recording of all suspected cases of OSD.⁷ It enables the calculation of incidence rates of OSD as a proportion of the employed population of Northern Bavaria as recorded by the German Federal Employment Office (Bundesanstalt für Arbeit).

The construction workers studied were patch-tested on the back, in the absence of eczema, by dermatologists who used the standard series of patch test allergens and standard methodology.⁸ The results were recorded according to the recommendations of the International Contact Dermatitis Research Group (ICDRG) and the German Contact Dermatitis Group (DKG).^{9,10} Finally, each positive reaction was interpreted, and its occupational relevance was assessed by a government physician dealing with OSD (Staatlicher Gewerbearzt).^{11,12} For each worker, the potential atopic skin diathesis was assessed using a score established previously by Diepgen *et al.*^{13,14}

Statistics

Incidences were calculated as cases per 10 000 employees including 95% confidence intervals. All calculations were made using SAS[®] 8.2 Win (SAS Institute Inc., Cary, NC, U.S.A.). Categorical variables were summarized by absolute and relative frequencies

in the case of outcome. Continuous variables were summarized by the mean, median, standard deviation, and minimum and maximum.¹⁵

Results

Incidence of occupational skin disease in the construction industry

In the construction industry, altogether 491 initial reports (IR) were observed. Out of them 335 OSD (68.2%) were registered. These comprise 9.0% of all cases of OSD in the BKH-N. We classified them into four relevant groups: (A) construction and cement workers (177 cases of OSD), including bricklayers (105), cement workers (30), unskilled construction workers (28) and plasterers (14); (B) tile setters and terrazzo workers (52); (C) wood processors (51), including carpenters (22) and tillers (29); and (D) painters (55). The overall incidence was 5.1 per 10 000 employees [95% confidence interval (CI) 4.5; 5.6] over 10 years which is a little below the average of the entire BKH-N (6.7). When the data were subdivided into the four relevant occupational groups, tile setters and terrazzo workers had the highest incidence rate with 19.9 cases per 10 000 employees (95% CI 14.9; 26.1), followed by painters with 7.8 (95% CI 5.9; 10.2), construction and cement workers with 5.2 (95% CI 4.4; 6.0) and, finally, wood processors with 2.6 (95% CI 1.9; 3.4) (Table 1).

Age and age-related incidence

In the construction industry, workers who initially reported OSD were between 17 and 65 years old, with a median age of 35 years. The median age of the occupational groups ranged from 31 years (wood processors) to 39 years (construction and cement workers). Of the workers with OSD, 44% (146) were at least 40 years old (Table 2).

Table 1. Incidences of occupational skin diseases (OSD) in the construction industry and demographic characteristics

	Initial report of OSD <i>n</i>	OSD 1990–99						
		Total		Incidence per 10 000	Age (years)			
		<i>n</i>	%		Mean	Median	Minimum	Maximum
BKH-N	5285	3730	70.6	6.7	31.2	27	15	73
Construction industry	491	335	68.2	5.1	38.7	35	17	65
Construction/cement workers	238	177	74.4	5.2	39.7	39	18	63
Tile setters/terrazzo workers	60	52	86.7	19.9	38.2	35.5	18	65
Painters	101	55	54.5	7.8	36.6	33	17	63
Wood processors	92	51	55.4	2.6	37.8	31	18	62

Table 2. MOAHLFA index of occupational skin diseases (OSD) in the construction industry

	IR construction industry n (%)	OSD construction industry n (%)	Tile setters/ terrazzo workers n (%)	Painters n (%)	Construction/ cement workers n (%)	Wood processors n (%)	BKH-N 1990-99 n (%)
Male	29 (5.9)	316 (94.3)	51 (98.1)	45 (81.8)	173 (97.7)	47 (92)	2261 (42.8)
Occupational	335 (68.3)	335 (100)	52 (100)	55 (100)	177 (100)	51 (100)	3730 (70.6)
Atopic dermatitis	75 (15.3)	38 (11.3)	3 (5.8)	8 (14.6)	17 (9.6)	10 (19.6)	1041 (19.7)
Hand dermatitis	328 (66.8)	247 (73.7)	37 (71.2)	39 (70.9)	130 (73.4)	41 (80.4)	4762 (90.1)
Leg dermatitis	54 (11.0)	23 (6.9)	4 (7.7)	3 (5.4)	13 (7.3)	3 (5.9)	407 (7.7)
Face dermatitis	81 (16.5)	39 (11.6)	5 (9.6)	4 (7.3)	20 (11.3)	10 (19.6)	824 (15.6)
Age > 40 years	208 (42.4)	146 (43.6)	19 (36.5)	21 (38.2)	85 (48.0)	21 (41.2)	1348 (25.5)
Total	491	335	52	55	177	51	5285

MOAHLFA, percentage Male, Occupational, Atopic dermatitis, Hand dermatitis, Leg dermatitis, Face dermatitis, Age > 40 years.

Table 3. Percentage of atopic skin diathesis, allergic and irritant CD in construction workers with occupational skin diseases

	BKH-N n (%)	Construction industry n (%)	Construction/ cement workers n (%)	Tile setters/ terrazzo workers n (%)	Wood processors n (%)	Painters n (%)
Allergic CD	2238 (42.4%)	206 (61.5%)	126 (71.2%)	39 (75.0%)	25 (49.0%)	16 (29.1%)
Irritant CD	2048 (38.8%)	149 (44.5%)	68 (38.4%)	20 (38.5%)	24 (47.1%)	37 (67.3%)
Atopic skin diathesis	1838 (34.8%)	89 (26.6%)	43 (24.3%)	12 (23.1%)	16 (31.4%)	18 (32.7%)

BKH-N, Berufskrankheitenregister Haut-Nordbayern; CD, contact dermatitis.

Sex

Male workers developed OSD much more frequently (316 OSD; 94%) than female workers (19 OSD; 6%). However, the overall incidence of OSD in the construction industry was 16.2 (95% CI 9.7; 25.2) for women compared with 4.9 (95% CI 4.3; 5.4) for men. The explanatory power of these data is restricted, however, due to the small number of women involved. These women work mainly as wood processors or painters. Strikingly, female painters had a very high incidence of 50.7 (95% CI 24.4; 93.2) in contrast with male painters with 6.6 (95% CI 6.6; 8.8), yet this finding must be interpreted with caution because of the small sample size.

Time in occupation

Construction and cement workers developed skin problems after a median of 12 years in this occupation. This is the longest period for any occupational group within the BKH-N, and is followed by wood processors with a median exposure of 6 years, painters (5 years) and tile setters and terrazzo workers (5 years).

Location

As anticipated, hands were the most frequent location of OSD (74%) for construction workers, followed by the face (12%) and legs (14%). Wood processors had a large proportion of facial dermatitis (Table 2).

Atopic skin diathesis

Of the construction workers with OSD, 27% had an atopic skin diathesis (ASD) compared with 35% in the BKH-N. Painters (33%) and wood processors (31%) with OSD had a higher prevalence of ASD than both construction and cement workers (24%) and tile setters and terrazzo workers (23%) (Table 3).

Irritant compared with allergic contact dermatitis

In the construction industry, occupationally induced ACD (206 patients) occurred more frequently than ICD (149 patients). However, it is known that patients with mild ICD seldom report their ailment or seek treatment; this may be the reason for the excess of cases of ACD in this collection of patients. In some cases both ACD and ICD were diagnosed.

Table 4. Allergens in the construction industry

Allergen	Positive patch test <i>n</i>	Clinically relevant <i>n</i> (%)	Occupationally relevant <i>n</i> (%)
1. Potassium dichromate	162	151 (93)	152 (94)
2. Epoxy resin	43	40 (93)	40 (93)
3. Cobalt chloride	67	40 (60)	32 (48)
4. Patient's own material	30	23 (77)	21 (70)
5. Thiuram mix	22	14 (64)	14 (64)
6. Nickel sulphate	43	17 (40)	11 (26)
7. <i>p</i> -phenylenediamine	31	13 (42)	9 (29)
8. Colophony	15	9 (60)	5 (33)
9. Potassium-chrome-(III)-sulphate	6	6 (100)	6 (100)
10. Benzoylperoxide	10	4 (40)	4 (40)
11. 4,4'-diaminodiphenylmethane (DDM)	11	6 (55)	5 (45)
12. Mercapto mix	6	4 (67)	4 (67)
13. Carba mix	5	3 (60)	3 (60)
14. Black rubber	5	4 (80)	3 (60)
15. Turpentine	4	2 (50)	2 (50)

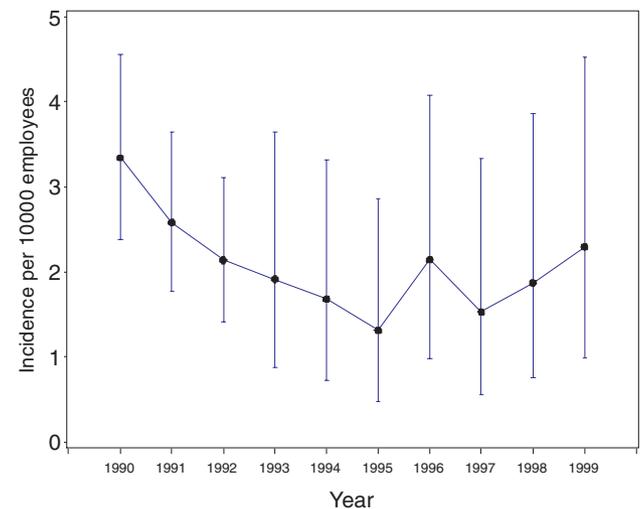
Conspicuously, there are major differences between the four occupational groups. While the majority of tile setters and terrazzo workers, as well as construction and cement workers, had ACD (75% and 71%, respectively), wood processors and painters were more prone to ICD (47% and 67%, respectively) (Table 3).

Allergens

The most important allergen in the construction industry is potassium dichromate. It causes about half of all cases of sensitization discovered to be occupationally relevant (OR) in the construction industry. In patch tests, 162 positive reactions were seen, of which 152 (94%) were OR, followed by epoxy resin (40 OR, 93%), cobalt chloride (32 OR, 48%), thiuram mix (14 OR, 64%), nickel sulphate (11 OR, 26%), *p*-phenylenediamine (nine OR, 29%) and colophony (five OR, 33%). Only by testing a patient's own work materials could 21 unspecified allergens be found (Table 4). When the allergens of the occupational groups are compared, painters differ conspicuously from the other groups. For them, the most important occupationally relevant allergen is epoxy resin rather than potassium dichromate (Table 5). The yearly incidence of occupationally relevant potassium dichromate sensitization did not change significantly during the study period, and fluctuated between 3.3 and 1.3 per 10 000 employees over the years (Fig. 1).

Table 5. Allergens most often seen by occupational groups in the construction industry

	Positive patch test <i>n</i>	Clinically relevant <i>n</i> (%)	Occupationally relevant <i>n</i> (%)
I. Construction/cement workers			
1. Potassium dichromate	116	112 (96)	113 (97)
2. Cobalt chloride	46	27 (59)	22 (48)
3. epoxy resin	22	21 (96)	21 (96)
4. <i>p</i> -phenylenediamine	18	9 (50)	5 (28)
5. Nickel sulphate	16	8 (50)	4 (25)
6. Thiuram mix	10	6 (60)	6 (60)
II. Tile setters/terrazzo workers			
1. Potassium dichromate	31	28 (90)	28 (90)
2. Nickel sulphate	12	5 (42)	5 (42)
3. Cobalt chloride	11	9 (82)	8 (73)
4. Epoxy resin	9	8 (89)	8 (89)
5. Thiuram mix	6	4 (67)	4 (67)
III. Wood processors			
1. Potassium dichromate	9	8 (89)	8 (89)
2. Nickel sulphate	7	2 (29)	2 (29)
3. Epoxy resin	5	5 (100)	5 (100)
IV. Painters			
1. Nickel sulphate	8	2 (25)	0
2. Epoxy resin	7	6 (86)	6 (86)
3. Cobalt chloride	7	6 (43)	1 (14)
4. <i>p</i> -phenylenediamine	7	3 (43)	3 (43)
5. Potassium dichromate	6	3 (50)	3 (50)
6. Thiuram mix	5	3 (60)	3 (60)

**Figure 1.** Incidence rates and 95% confidence interval of occupational relevant dichromate sensitization between 1990 and 1999 in the construction industry.

Discussion

Overall from 1990 to 1999, the study centre of the BKH-N obtained 5285 initial reports of OSD of which 3024 were females (57.2%) and 2261 males (42.8%).

After examination by a government physician, OSD were suspected in 3730 of the cases in the IR (70.6%). Of all cases, 1555 (29.4%) were not related to the workplace. On average, during the first study period from 1990 to 1992, the incidence of developing a new skin disease was 10.7 per 10 000 workers per year, a figure that declined significantly to 4.9 in the second study period from 1993 to 1999.⁷

The mean age of workers with OSD in the construction industry is relatively high: it is 39 years compared with 27 years for the entire BKH-N. Although this is less than was reported in a study by Condé-Salazar *et al.* (45 years), this documents the above average age of OSD in this occupational group.¹⁶ Construction and cement workers with the highest mean age in this report of 39.7 years are known to have an especially long latency before skin lesions appear.¹⁶

The incidence of OSD in the construction industry from 1990 to 1999 is 5.1 cases per 10 000 employees, which is below the average of the whole BKH-N (6.7). When the four investigated occupations are considered, there are substantial differences. Tile setters and terrazzo workers have a high risk of developing OSD (incidence 19.9), but wood processors are rarely affected. Analysis of the most important allergens for tile setters and terrazzo workers discovered them to be potassium dichromate ($n = 28$), cobalt chloride ($n = 8$) and epoxy resin ($n = 8$). These data do not differ from those of the construction and cement workers.

More than 73.7% of the workers with OSD suffered from hand dermatitis followed by 11.6% with facial dermatitis and 6.9% with leg dermatitis. Comparing these results with the initial reports, the percentage of hand dermatitis is lower (66.8%) and that of facial and leg dermatitis is higher (16.5% and 11.0%). The suspicion of an OSD seems to apply less often for locations other than the hands. Other investigations registered only about 60% hand dermatitis.^{16,17}

Although the majority of workers with OSD had ACD, major differences in the four analysed occupational groups were found. While 71.2% of the construction and cement workers as well as 75.0% of the tile setters and terrazzo workers had ACD, wood processors and painters had a high percentage of ICD (47.1% and 67.3%). The relation between cases of ICD and ACD of cement workers differs in the literature. While some authors such as Irvine *et al.* and Condé-Salazar *et al.* found a majority of cases of ACD, Goh *et al.* and Roto *et al.* reported a majority of cases of

ICD.^{18–21} In our investigation we found a majority of cases of ACD in the construction industry (61.5%). The predominance of ACD could be a consequence of milder unreported cases, which are known to be caused particularly by irritants.²²

The most important allergen is still potassium dichromate. Of all occupationally relevant sensitization, 54.6% of that found in construction and cement workers and 44.5% of that found in tile setters and terrazzo workers was caused by potassium dichromate. The estimated costs of dichromate-induced contact dermatitis in Germany are about 35 million € per year without considering the costs of sickness days.²³ These data clarify that chromate allergies remain an important health problem in the construction industry. Furthermore, the symptoms often persist even after affected workers change their occupation to avoid chromate exposure.²⁴

In 1981, the prevalence of chromium allergy in construction workers was reported to be 5.5% in Singapore and 8.9% in Denmark.²⁵ The prevalence decreased significantly in the small Danish database from 8.9% to 1.3% after use of cement with reduced levels of chromium VI by adding ferrous sulphate to cement was introduced.²⁶ In another Danish investigation the Danish Contact Dermatitis Group ascertained a significant decrease of contact allergy to potassium dichromate from 3% in 1985–86 to 1.2% in 1997–98, suggesting that this is a consequence of adding ferrous sulphate to Danish cement in 1983.⁶ The effect of ferrous sulphate is based on reducing water-soluble chromium VI to less soluble chromium III in wetted cement. The penetration of chromium VI into the epidermis is much higher than that of chromium III.²⁷ Fullerton *et al.* found no significant difference in chromium content in human skin after *in vitro* application of ordinary cement and ferrous-sulphate-reduced cement.²⁸ A discussion began about whether this decrease was a consequence of adding ferrous sulphate or of improved hygienic conditions, skin protection and an increase in the use of prefabricated cement elements.²¹ In Germany the recent statistics provided by the Berufsgenossenschaften der Bauindustrie (social insurance institution of the construction industry) documented approximately 300 new contact dermatitis cases per year caused by chromium with an increasing incidence during the second half of the 1990s.¹ Therefore, in 1998 the German construction industry committed itself to producing only chromate-reduced cement with less than 2 mg kg⁻¹ (p.p.m.) of chromium VI in the

anhydrous mass accepting much higher concentrations in the dry cement.²⁹ After revision in October 2002, this limit became mandatory for dry cement.³⁰

In an interesting case study, two bricklayers with chromate allergy and chronic allergic hand dermatitis were provided cement supplemented with tin sulphate leading to soluble chromate concentrations of 0.1 p.p.m. Within 4 weeks of work with this grout their skin conditions had clearly improved.²³ Burckhardt *et al.* had already reported in the early 1970s on chromium-allergic patients who did not react to a solution of cement in water after adding 0.3% of ferrous sulphate.³¹

Until 1999 there was no reduction of chromate-induced OSD in the BKH-N in Germany. This contrasts with the Scandinavian data and indicates that a decrease of chromium VI in cement through the addition of ferrous sulphate leads to a decline of chromate-induced OSD. Future data will reveal whether the German measure of reducing chromium VI in dry cement will be effective. A recently published report of the newly established Saarland register with data from 1999 till 2001 documented similar incidences for construction and cement workers compared with the BKH-N.³²

Epoxy resin is the second common occupational relevant allergen in the construction industry and the most important for painters in this collective. Epoxy resin presents a high risk of sensitization and causes severe ACD, which often also affects locations other than the hands, such as the face.^{11,33} Workers with sensitization to epoxy resin should generally be recommended to change their workplace and to avoid any further contact with these substances. This emphasizes the importance of adequate preventive measures.

Analogue to other reports, we found a high prevalence of occupationally relevant cobalt chloride sensitization ($n = 32$). Thirty-one (97%) had concomitant occupationally relevant potassium dichromate sensitization. Thus, these data support observations that cobalt is the most common source of cosensitization among chromate-allergic subjects.³⁴

In 21 cases with ACD, the allergen could only be found by testing the patient's own materials handled at work. There are probably more cases of ACD that remain unknown.³⁵ This points out that testing patient-supplied materials is an important clue in revealing causative agents.³⁶

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