

Incidence of work-related hand eczema during apprenticeship: first results of a prospective cohort study in the car industry

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Data on the incidence and prevalence of occupational contact dermatitis (OCD) are scarce, and most of our knowledge about OCD is derived from clinical case reports or clinical studies of in- and out-patients. Therefore, we investigated in the epidemiological, prospective Audi cohort study (PACO study) the incidences of work-related hand eczema in different apprenticeships of Audi AG. In total, 2078 apprentices were investigated at the start of their apprenticeship and systematically followed up over a 3-year period. At the end of the study, information on 2042 (98.2% follow-up) apprentices was available. The 1-year cumulative incidences of hand eczema were 9.2% (95%-confidence interval 7.8–10.7) in metalworkers, 8.8% (95%-CI 7.0–10.7) in other blue-collar workers, and 4.6% (95%-CI 2.3–8.1) in white-collar apprentices. The 3-year cumulative incidences of hand eczema were 15.3% (95%-CI 13.6–17.2) in metalworkers, 14.1% (95%-CI 11.8–16.5) in other blue-collar workers, and 6.9% (95%-CI 4.0–10.9) in white-collar apprentices. In females, the cumulative incidence of hand eczema was higher compared to men (1-year incidence 10.1%, 95%-CI 7.7–13.0, versus 8.3%, 95%-CI 7.1–9.5; 3-year incidence 16.1%, 95%-CI 13.1–19.5 versus 13.6%, 95%-CI 12.2–15.2). In some occupations, like cooks, tool mechanics, milling cutters and varnishers, the incidence of hand eczema was significantly increased. In those occupations, however, no job change was necessary, and no notifiable occupational contact dermatitis occurred. The incidence was not uniformly distributed over the 3-year period. Within the first 6 months, a particularly high rate of hand eczema occurred, which then declined and remained steady at a lower rate over the 2nd and the 3rd years. The results of our study give important suggestions for preventive measures at the workplace and effective occupational pre-employment advices.

Key words: occupational; contact dermatitis; prospective cohort study; epidemiology; car industry; apprentices; metalworkers; cooks; paint sprayers. © Munksgaard, 2001.

Accepted for publication 14 September 2000

Understanding the epidemiology of occupational contact dermatitis (OCD) is essential for determination of etiologic and contributing factors of the disease and to make recommendations for its prevention. Only a few truly epidemiological cohort studies of OCD have been published, and most of our knowledge about OCD is derived from clinical case reports, clinical studies of groups consisting of in- and out-patients, statistical compilations of patch test reports, official occupational disease reports based on workers' compensation agencies and state labor & health departments, or from studies of small outbreaks of skin diseases at the workplace. All these data sources have their limitations and must be interpreted carefully (1).

Between 1990 and 1998, the *Prospective Audi Cohort* (PACO) study monitored the development

of hand eczema in the different apprenticeships of Audi AG. The purpose of the study was the evaluation of job-related hand eczema (HE) with respect to different typical patterns of exogenous and endogenous risk factors, i.e., atopic skin disease. The study was conducted with close long-term co-operation of dermatologists and occupational physicians. In this 1st complete publication, general information on study design, materials, methods and descriptive overall results of the study are given.

Material and Methods

Study design

All 2078 apprentices at the automobile manufacturer Audi AG, who started their apprenticeships

Table 1. Parameters of the study

Parameter	1st examination occupational physicians	2nd examination dermatologists	3rd examination dermatologists
skin history	×	×	
atopic features	×	×	
domestic skin hazards	×	×	×
cleansing of the skin		×	×
use of barrier creams		×	×
irritants at the workplace			×
hand eczema		×	×

in Ingolstadt in 1990–1994 and in Neckarsulm in 1991–1994, were included in the study during their 3-year apprenticeships. These apprenticeships included metalworkers (58%), other blue-collar workers (33%) and white-collar occupations (9%). In a prospective cohort study design, with examinations carried out before the start of the apprenticeship, after the 1st year and at the end of the apprenticeship, the following risk factors of HE were investigated: atopic skin disease, history of HE, domestic risk factors, exposures to irritants at the workplace and use of barrier creams. Specially-trained occupational physicians performed the 1st examinations at the job application stage. The results of the study were not affected by any pre-employment selection with respect to skin susceptibility by the company or by the occupational physicians. Because the 1st examinations were part of the regular pre-employment examinations at that time, the subjects of the study were not aware of a study situation. Information on the structure and the aims of the study was given to the participants after the start of apprenticeship. 2nd and 3rd examinations were performed by dermatologists, who also recorded the outcome variable hand eczema. None of the participants refused examination, and a follow up of 98.3% was achieved.

Parameters and instruments

The parameters of the study are shown in Table 1. Irritants at the workplace were recorded within different apprenticeship fields and particularly in the last 4 weeks prior to the occurrence of a HE. Already in existence were standardized complete job and work process descriptions, especially during the 1st year of the apprenticeship. These descriptions supported the recording of exposure at the workplace. Additional parameters were medication and alcohol consumption, recorded at the 2nd examination, and cigarette smoking, recorded at the 2nd and 3rd examination.

All 3 questionnaires utilized in the study were pre-tested. In particular, the questionnaire used in

the 1st examination by occupational physicians was tested in advance and then modified in accordance with the results of a sample of 40 test-examinations. An additional instruction paper, including exact definitions of all parameters and photographs of skin findings, was used by the investigators at the 1st examinations (occupational physicians).

The diagnosis of hand eczema (outcome variable) was set up by dermatologists in accordance with the following definition: reported skin problems during the apprenticeship on the hands and/or forearms. Not included as cases of HE were: reported dry skin without any other symptoms, minimal skin symptoms like redness or scaling, dyshidrosis lamellosa sicca with no hints of worsening, and (definitively diagnosed) mycosis. In certain cases, the final diagnosis of HE was corroborated by the information obtainable from the files of the occupational physicians, when HE was acute. Statistical analyses were executed by SPSS and SAS.

Results

Follow-up

At the job application stage, in total, 2222 examinations were performed. 2078 subjects started the apprenticeship and were included in the study. The follow-up is shown in Table 2.

Drop-out tracing was carried out by a ques-

Table 2. Follow-up of the prospective Audi cohort (PACO) study

	N	(%)
start of apprenticeship/study	2078	100.0
drop-outs trail period (3 months)	40	1.9
drop-outs trail period–2nd examination	46	2.2
2nd examinations	1990*	95.8
drop-outs 2nd examination –		
3rd examination	82	3.9
3rd examinations	1910	91.9
drop-outs total	168	8.1

* Two 2nd examinations not performed (long-term illness).

tionnaire on HE from all participants of the study who left the company before the end of apprenticeship. Out of a total of 168 drop-outs, 132 answered this questionnaire; therefore, information on the outcome variable was available from 2042 (1910+132) subjects, i.e., a total follow-up of 98.3% (2042/2078) was achieved. Out of the remaining 36 subjects, in 15 cases, it was established that the possible occurrence of HE had no relevance to the act of leaving the company. In the last 21 cases (3 deaths, 7 long-term illness), absolutely no information on the outcome variable was obtainable. Here, also the context of instant dismissals played an important rôle.

In the drop-out questionnaire, 6 out of 132 subjects (4.5%) reported a HE. However, in 3 cases, the subjects declared that this HE was relevant to breaking-off the apprenticeship. The evaluation of these cases showed that, in 2 of the subjects, a HE occurred before the start of the apprenticeship. In all 3 cases it still remains suspicious as to whether the HE was the true reason for leaving the company, as the subjects never contacted their instructors or the occupational physician regarding this question, and all 3 had occupations with only moderate skin hazards.

Changes of career within the apprenticeship were observed only in 21 cases. 13 metalworkers moved to another metalwork-apprenticeship, 7 into another blue-collar apprenticeship and 1 apprentice from another blue-collar job moved to a metalwork-apprenticeship. These results demonstrate that the observed cohort was quite stable. The frequency of HE among drop-outs (4.5%) and in addition the shorter time at risk, confirm, in comparison with the later reported HE frequen-

First occurrence of hand eczema (N=261)

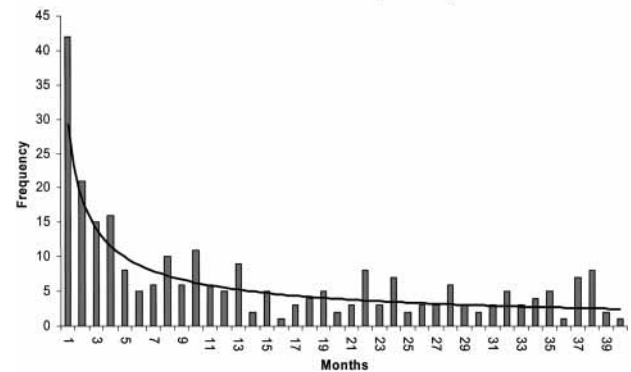


Fig. 1. Incidence of hand eczema during the 36-month study period.

cies, that the results of the study were not biased by any selection. Nevertheless, the self-selection of an apprenticeship in respect of the personal history of HE and possible skin hazards remains a relevant factor in this study design.

In Table 3, the demographic characteristics of the study cohort are given. It is of relevance to the study that the sex distribution varied in the different apprenticeships.

Occurrence and course of hand eczema

The overall 1-year and 3-year cumulative incidences of HE are given in Table 4. The incidence was not uniformly distributed over the 3-year period. Within the first 6 months, a particularly high rate of HE occurred, which then declined and remained steady at a lower rate over the 2nd and most of the

Table 3. Demographic characteristics of the study cohort

	Male		Female		Total	
	N	(%)	N	(%)	N	(%)
total number	1524	(100)	386	(100)	1910	(100)
metalworkers	992	(65.1)	118	(30.6)	1110	(58.1)
other blue-collar	503	(33.0)	123	(31.9)	626	(32.8)
white-collar	29	(1.9)	145	(37.6)	174	(9.1)
age (median)						
1st examination	15.7 years		16.0 years		15.8 years	
3rd examination	19.3 years		19.2 years		19.3 years	

Table 4. 1-year and 3-year cumulative incidence of hand eczema (HE) in apprentices

	N	1-year incidence HE			3-year incidence HE		
		N	(%)	95% CI	N	(%)	95% CI
male	1524	126	8.3	7.1–9.5	208	13.6	12.2–15.2
female	386	39	10.1	7.7–13.0	62	16.1	13.1–19.5
total	1910	165	8.6	7.6–9.8	270	14.1	12.8–15.5

Table 5. Predictive values of hand eczema (HE) in different occupations

	N	1-year incidence HE			3-year incidence HE		
		N	(%)	95% CI	N	(%)	95% CI
metalworker							
male	992	85	8.6	7.1–10.2	146	14.7	12.9–16.7
female	118	17	14.4	9.4–20.9	24	20.3	14.4–27.4
total	1110	102	9.2	7.8–10.7	170	15.3	13.6–17.2
(other) blue-collar							
male	503	40	8.0	6.1–10.2	61	12.1	9.8–14.8
female	123	15	12.2	7.7–18.2	27	22.0	16.0–29.0
total	626	55	8.8	7.0–10.9	88	14.1	11.8–16.5
white-collar							
male	29	1	3.4	0.2–15.3	1	3.4	0.1–15.3
female	145	7	4.8	2.3–8.9	11	7.6	4.3–12.2
total	174	8	4.6	2.3–8.1	12	6.9	4.0–10.9

3rd year. At the end of the 3-year period, the HE incidence increased slightly (Fig. 1).

Approximately 33% of the diagnosed HE were isolated incidents, 59% were classified as recurring and 8% as continuous. Overall, only 41% of the subjects with a HE visited any doctor for diagnosis and therapy. Dermatologists were visited in 21%, occupational physicians in 15% and family doctors (GPs) in 9% of the HE cases. Only 2.5% of the

diagnosed HE were associated with sick leave. No HE triggered the official notification of an occupational disease and only in 1 case was a dermatologist's report of possible occupational skin disease notified to the insurance institution.

Out of 241 HE, 226 (93.8%) were irritant HE, and 15 (6.2%) allergic HE (1 definite, 2 probable and 12 possible cases).

The frequencies of HE in different occupational groups are shown in Table 5 and Fig. 2. The 3-year incidence of metalworkers and other blue-collar occupations vs. white-collar jobs differed significantly in women and in total. Finally, in Table 6 and Fig. 3, the predictive values for the risk of HE (3-year cumulative incidence) in the different apprenticeships are shown. These evaluations are based only on the 1897 subjects without any change in career.

Evaluation of the incidence of HE in different occupations shows significant differences between exposed and non-exposed subjects. These differences could already be observed in the 1st year of

Table 6. Predictive values of hand eczema (3-year incidence) in different occupations

Apprenticeship	N	HE		
		N	(%)	95% CI
catering specialists	14	0	0.0	0.0–19.3
white-collar (clerical) occupations	174	12	6.9	4.0–10.9
stock control specialists	58	4	6.9	2.4–15.1
electronic engineers: production	220	18	8.2	5.4–11.9
light sheet metal				
construction specialists	98	11	11.2	6.4–17.9
mechanics: facilities	44	5	11.3	4.6–22.4
industrial mechanics: production	166	21	12.7	8.6–17.7
mechanics: technical equipment	39	5	12.8	5.2–25.1
tool-mechanics: systems	179	26	14.5	10.4–19.6
body-in-white constructors	48	7	14.6	7.1–25.7
automobile electricians	120	18	15.0	9.9–21.4
automobile mechanics	264	40	15.2	11.6–19.3*
lathe-operators	57	9	15.8	8.5–25.9
model-makers	36	6	16.6	7.5–30.3
industrial mechanics: systems	183	34	18.6	14.0–24.0*
paint-sprayers	54	11	20.4	11.9–31.5*
milling-machine operators	57	13	22.7	15.8–33.8*
tool-mechanics: manual				
cooks	51	14	27.5	17.4–39.5*
other apprenticeships (4)	13	8	61.5	35.5–83.4*
other apprenticeships (4)	22	5	22.7	9.4–42.0

* Predictive value differs significantly versus white-collar occupations.

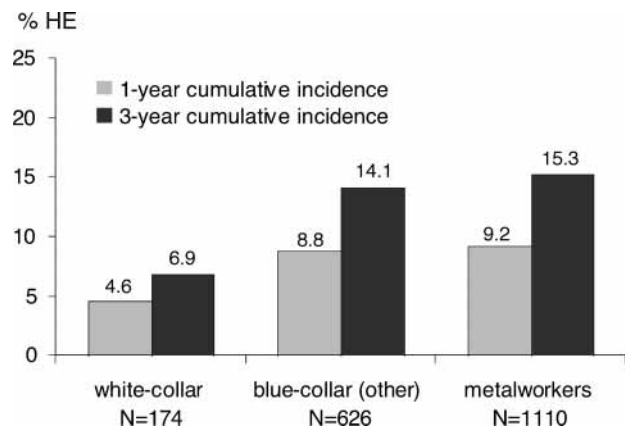


Fig. 2. 1- and 3-year incidences of hand eczema in different occupational groups (apprentices).

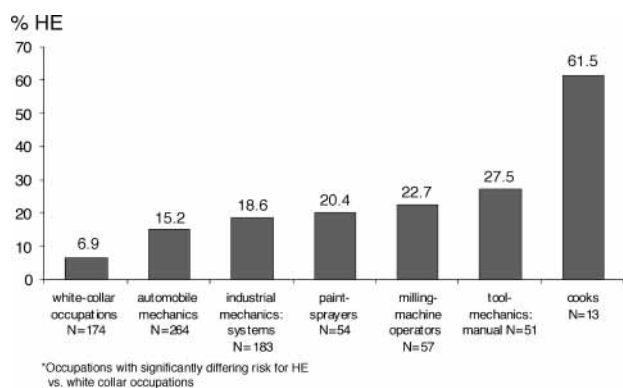


Fig. 3. 3-year incidence of hand eczema in different apprenticeships.

apprenticeship. Within 3 years, metalworkers and other blue-collar workers had a significant $2\times$ elevated HE risk compared to white-collar occupations (Fig. 3). In women, this risk elevation was almost $3\times$ (Tables 4, 5). It has to be taken into account that HE incidence within the 1st year occurs mainly among subjects with susceptible skin, obscuring exposure-related HE incidence. During the following years, this aspect loses relevance. Evaluation of the HE frequency in particular occupations offers further information on job-related risk groups. A fairly stable correlation between exposure at the workplace and frequency of HE could be confirmed. Unexposed subgroups like white-collar (clerical) occupations had only 1/2 the HE frequency of most of the mechanics with moderate exposures at the workplace. In contrast, occupations with a heavier exposure to irritants, like paint sprayers, milling-machine operators, tool mechanics (manual) and cooks had a significant $3\times$ and above elevated HE frequency versus unexposed subjects (Table 6).

Discussion

In this prospective cohort study, the rôle of endogenous and exogenous risk factors for HE was investigated in the automobile industry. From the epidemiological point of view, the characteristics of the study are as follows.

(i) The results were not affected by any refusal of examinations or drop outs and a quite stable cohort was monitored.

(ii) Relatively large subgroups with similar exposures at the workplace and well-defined standardized job descriptions during apprenticeships were identified.

(iii) In general, no former exposures to irritants at the workplace had to be taken into account.

(iiii) A similar socio-economic background of participants.

(iiii) The utilization of the organisational power of a big company with a well-established department of occupational medicine allowed epidemiological evaluations with considerable power.

According to the working conditions of an advanced company, only the effects of moderate exposures at the workplace could be assessed, but they may be representative for a major proportion of workplaces, not only in the automobile industry.

In population-based studies of hand eczema, different prevalence rates are reported (e.g., 2–4), related to differences in methodology, identification of persons with contact dermatitis and disease definition. A study in a Swedish city demonstrates the difference between point and period prevalence: in the same population, the point prevalence of hand eczema was 5.4% and the 1-year period prevalence 10.6% (4). In all these studies, the prevalence among women was higher than among men. Irritant hand eczema is more common than allergic hand eczema.

In an epidemiological study on the prevalence of hand eczema in different occupational groups, it was noted that in population-based studies, the symptoms of contact dermatitis are relatively mild in the majority of cases, judged by the proportion of cases that resulted in sick leave or medical attention (5); in that study, out of all persons with work-related hand dermatitis, only between 15% and 36% had consulted a physician and sick leave resulted in only 4% to 9%. These findings are in close accordance with our study.

In a population-based prospective study on notified cases with occupational skin diseases in North Bavaria, the highest incidence rates were found in hairdressers, bakers, electroplaters, and metalworkers (6). The induction period was very short: about 2 years in hairdressers, 3 years in the food industry, and about 4 years in health service and in metalworkers. In the food industry, bakers had a particularly high risk of occupational contact dermatitis (7). Women had a considerably higher risk of developing OCD than men.

The incidence of hand eczema is extremely high in the hairdressing trade (8–10). In a prospective cohort study in hairdressers (8), 68% of the hairdressers developed mild, moderate or severe hand eczema during the 1st year of apprenticeship. In the study of Uter et al. (9), the point prevalence of “skin changes” observed in those examined increased from 34.4% at the 1st examination, on average 8 weeks after the onset of occupational exposure, to 47.5% at the 2nd and 55.1% at the final examination. The incidence rate, i.e., the number of newly diseased study participants in relation to the person-time at risk contributed, decreased in the course of the study and amounted to 34.3 cases

of skin changes per 100 person-years for the total study period. In this study, however, the majority (51.8%) of initial participants could not be followed up completely. Smit et al. (10) followed 74 apprentice hairdressers and 111 apprentice nurses from the start of 1st occupational exposure until the end of their apprenticeship. The average incidence rate of hand dermatitis was 32.8 cases/100 person-years in hairdressers and 14.5 cases/100 person-years in nurses. The relative risk to hand eczema of having a dry versus normal skin type was 7.3 in hairdressers and 1.7 in nurses. Apprentice nurses with a history of (atopic) mucosal symptoms had a 3.4 $\times$ increased risk of hand dermatitis, in apprentice hairdressers this being 2.2.

In the PACO study, the basic results on occurrence and course of HE reveal that allergic hand eczema is rare at only 6.2% of all HE. This finding is corroborated by the study of Kristensen (11), who investigated new employees in the automobile manufacturing industry. In this study, on average 4.4% acquired hand eczema during the 1st year of employment. The risk was significantly higher in individuals with previous hand eczema (21%), atopic dermatitis (14%), wool intolerance (11%), and hay fever (9%).

It has to be pointed out that in our study, only 1 allergic HE was definitively diagnosed by a dermatologist and in that case, the allergen was in a barrier cream. In 2 cases, an allergic HE was more probable than, for example, an irritant HE. In 12 cases, an allergic HE was possible, but another ethiology seemed to be more probable. The background of these diagnostic decisions was mainly the course of the symptoms in comparison with the changing exposures at the workplace, corroborated by patch testing and, if necessary, re-exposure at the workplace. To interpret this result, it has to be taken into account that the period of exposure is relatively short. Preceding long-term irritant or atopic HE are comparatively rare and, in contrast to clinical studies, 59% of subjects with a HE were included who normally would not visit any doctor.

The different distribution of the moment of the 1st occurrence of a HE (Fig. 1), with 43% of the incidence in the first 6 months and 61% of the incidence within the 1st year of standard 3-year apprenticeships, is known from other studies (9, 11). It shows that a majority of subjects with a susceptible skin acquires a HE within a quite short period. Irritant exposure at the workplace plays a role too, because in the exposed occupations the exposure in the 1st year was somewhat heavier than in the following 2 years of apprenticeship. It is notable that new HE occur continuously on the same level in the 2nd and 3rd years without any

decline. Finally, there was a slight rise in the HE-incidence at the end of the 3-year period.

Despite the distinct differences between occupational groups, no occupational skin disease that fulfilled the legal requirements (in Germany defined as severe and recurring dermatitis, which causes the loss of work) occurred in the apprenticeships with exposures. Additionally, no change of employment was recorded and, in the 13 excluded subjects with job-changes, only 3 cases with HE occurred and these cases were not relevant to the change. The results demonstrate that the epidemiological evaluation of nearly all occurring HE, which regularly will not be seen by any physician, gives important suggestions for the identification of job-related risk groups for HE. Furthermore, it should trigger the development of a more elaborate concept of irritant contact dermatitis, because it could be demonstrated that most of the definitively exposure-associated HE improved or disappeared despite ongoing exposure and was not relevant to job loss or change within a medium-length period.

In this publication only descriptive results are discussed. Atopy and other relevant confounders influence the explanation of the outcomes. In further publications the methods of analytical epidemiology will be used to analyse the distinctive effects of endogenous and exogenous risk factors for HE.

Conclusions

Based on careful clinical and epidemiological observation, it could be demonstrated that significant differences between HE risks already exist in different apprenticeships. Because the apprenticeships include all typical tasks and task-associated exposures to irritants at the workplace, the results are not only representative for the car industry but also for various occupations (with identical job description). Allergic HE did not play a significant rôle, whereas irritant HE in context with susceptible skin seems to be important.

Our results offer big possibilities for prevention, because risk groups for HE could be identified. Reduction of exposures and special medical advice can thus be initiated effectively before a severe or recurring HE forces the change or loss of a job. Additionally, the concept of special periodical examinations for the prevention of occupational skin diseases, and particularly the planning of intervals for periodical examinations (12), are underpinned by the outcomes.

Acknowledgements

The study has been financially supported by grants from the German Ministry for Research (BMBF,

No. 01HK899/3). We thank Oliver Kuss for the statistical analysis.

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