

Susceptibility to and incidence of hand dermatitis in a cohort of apprentice hairdressers and nurses

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OBJECTIVES — The role of atopic constitution, contact sensitization, transepidermal water loss, and dry skin in the development of hand dermatitis was investigated in a prospective study of 74 apprentice hairdressers and 111 apprentice nurses.

METHODS — Base-line measurements included a questionnaire on personal characteristics and anamnestic information, examination of hand skin, measurements of transepidermal water loss, patch tests, and prick tests. The condition of the hands, previous exposure, and transepidermal water loss were followed at intervals of four to six weeks. Cox proportional hazard models were used in the statistical analysis.

RESULTS — The average incidence rate of hand dermatitis was 32.8 cases per 100 person-years for the hairdressers and 14.5 cases per 100 person-years for the nurses. The rate ratio of having a dry versus normal skin type was 7.3 for the hairdressers [95% confidence interval (95% CI) 2.2–24.3] and 1.7 for the nurses (95% CI 0.5–6.4). Apprentice nurses with a history of (atopic) mucosal symptoms had a 3.4-fold increased incidence rate of hand dermatitis (95% CI 1.05–11.2). The rate ratio of mucosal atopy for the apprentice hairdressers was 2.2 (95% CI 0.7–6.7). Graphic display of the results suggested an increased risk of hand dermatitis among the apprentice hairdressers with transepidermal water loss on the hand greater than $15 \text{ g} \cdot \text{m}^{-2} \cdot \text{h}$, but the relative risk of increased transepidermal water loss was not statistically significant.

CONCLUSIONS — The most important endogenous risk factors for hand dermatitis among the apprentice hairdressers and nurses were the presence of dry skin and a history of mucosal atopy. No relationship between increased transepidermal water loss and the risk of hand dermatitis was observed.

KEY TERMS — atopic constitution, contact sensitization, dry skin, mucosal atopy, transepidermal water loss.

Under the same work conditions, some persons develop hand dermatitis and others do not. This is not just a matter of chance. Individual susceptibility plays an important role in the causation of hand dermatitis. Characteristics known to be associated with hand dermatitis are atopic background (in particular, atopic dermatitis), contact allergy (especially nickel allergy), and skin dryness (1–9). Over the last decade, several authors have suggested that base-line preexposure transepidermal water loss can serve as an indicator of individual susceptibility to the devel-

opment of contact dermatitis (10–13). The biological mechanism underlying this hypothesis is that a diminished barrier function of the skin, reflected by increased transepidermal water loss, allows harmful agents to pass through the stratum corneum more easily and cause damage in the underlying layers of the skin. However, the predictive value of an increased base-line transepidermal water loss for the risk of hand dermatitis has not yet been evaluated in epidemiologic studies.

A prospective study was performed among apprentice hairdressers and nurses with two objectives. One was to obtain quantitative estimates of the relationship between hand dermatitis and known risk factors such as atopic background, contact allergy, and type of skin. The other was to investigate the hypothesis that individuals with increased base-line transepidermal water loss as a personal characteristic are more susceptible to developing hand dermatitis during occupational exposure than those with low transepidermal water loss and similar exposure. Hairdressers and nurses were chosen as study populations because they are known to be at high risk for the development of hand dermatitis (2, 14–17).

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Subjects and methods

Study design and population under study

The study group consisted of 111 apprentice nurses and 74 apprentice hairdressers who were free of hand dermatitis at the start of the investigation. The apprentices were under observation during their training. They were examined at regular intervals to identify new cases of hand dermatitis and to record changes in occupational exposure. Figure 1 summarizes the design of the study.

Four groups of apprentice hairdressers, a total of 77 persons, were recruited at the start of their training in September 1990, December 1990, May 1991 or September 1991 (response rate 100%). Three apprentices left school before the first follow-up measurement was made. Therefore, 74 apprentice hairdressers were included in the study. The duration of the hairdressers' training averaged 10 months. Eight subjects, who failed their final examination, remained under observation until they were successful one to four months later. The study of hairdressers ended in May 1992, when the last determination was made in the fourth group.

Two groups of apprentice nurses, a total of 126 persons, were recruited in the third year of their training, which included the first period of practical training (response rate 86%). The first group was enrolled in October 1990. They were under observation for two years until the end of their training (July 1992). The second group was enrolled in October 1991 and was under observation until July 1992 (one school year). Four individuals who suffered from hand dermatitis at the start of the study were not included in the analysis. Eleven apprentice nurses dropped out for reasons unrelated to hand dermatitis before the first follow-up determination. Therefore, 111 apprentice nurses were included in the study. The first year of follow-up included two periods of practical work of 12 weeks each, with an interval of eight weeks of classes without occupational exposure. The second year of follow-up consisted of 12 weeks of classes followed by 20 weeks of practical work.

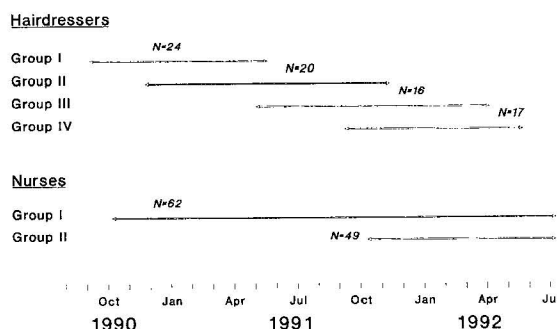


Figure 1. Design of the study.

Four hairdressers left school and were lost to follow-up after a minimum observation period of 22 weeks. Six apprentice nurses were lost during the first school year of observation for several reasons unlikely to be related to hand dermatitis (left school, lost interest in the study, lack of time, illness, or accident). Thirteen apprentice nurses of the first group were lost in the second school year, mostly because they had a different schedule for practical work.

Patch test readings were obtained for 97% of the apprentice hairdressers and for 75% of the apprentice nurses. Prick tests were performed for 99% of the hairdressers and 78% of the nurses. The major reasons for refusal to participate in the dermatological tests were fear or inconvenience. Prior dermatological testing was not given as a reason for refusal by any of the subjects.

Data collection

Baseline measurements. Data collection took place in an office at the hairdressers' and nurses' schools. At the time of entry into the study, the following protocol was adhered to:

1. A questionnaire was completed to determine relevant base-line characteristics such as age, gender, history of asthma or hay fever, history of childhood eczema, history of past skin disease, and prior exposure to hairdressing or nursing activities.

2. An examination of the skin of the hands was performed by a trained physician, and positive skin findings (one "A" sign or two "B" signs) were recorded (18). "A" signs were grouped papules, grouped pustules, grouped vesicles, and exudation. "B" signs were erythema, scaling, edema, fissures, and lichenification. The type of skin on the hands was recorded and graded as dry, normal, or oily.

3. Base-line measurements of transepidermal water loss (expressed as grams per square meter per hour) were performed on the forearm and the back of the dominant hand as indicators of the susceptibility of the skin. Measurements on the forearm were made on the volar side, 8 cm from the wrist. Transepidermal water loss was measured on the dominant hand, since this hand was assumed to have a similar probability of occupational exposure among the subjects. The evaporimeter EPIC (ServoMed AB, Kinna, Sweden) was used for measuring transepidermal water loss. The operating principle of the instrument is based upon measuring the vapor pressure gradient through the skin (19). The measurements were performed according to the guidelines proposed by the Standardization Group of the European Society of Contact Dermatitis (20). The exception was that the temperature and relative humidity ranged more widely in this study than what was proposed in the rec-

ommendations (20°C; 40% relative humidity). On the six occasions that base-line measurements were performed, the ambient air temperature varied between 16 and 24°C. The range in the relative humidity of the ambient air was 27–62%. Fluctuations in the measurement conditions were due mainly to the fact that the measurements were performed in the schools, where no air-conditioned rooms were available. Ambient air temperature and humidity were recorded before each measurement. The measurements of transepidermal water loss were recorded continuously on a chart strip recorder. All of the measurements were made in duplicate.

4. A thin-layer rapid use epicutaneous test (TRUE test, Pharmacia) was performed to determine the existence of cell-mediated allergy to common contact allergens at the start of the study (21). Patch testing was performed with the use of the European Standard Series, which included 23 of the most common allergens and one negative control. The patches were applied to the subjects' back and removed after 48 h. The patch tests were read by a dermatologist after 48 and 72 h. They were graded according to the recommendations of the International Contact Dermatitis Research Group (22).

5. Prick tests (Pharmacia) were carried out on the forearm to determine the existence of immediate type allergy. Test substances were pollen of birch, alder, timothy grass, dander of cat, dog and guinea pig, and house dust mite. Histamine was used as a positive control. Prick tests were read after 20 min by an experienced dermatologist.

Follow-up measurements. The follow-up measurements of the apprentice hairdressers took place at intervals of about six weeks. Those of the apprentice nurses were performed the week before and the week after each period of practical work. The following protocol was applied for each follow-up measurement.

1. A questionnaire was completed by all of the subjects to determine the incidence of symptoms of hand dermatitis over the preceding period and the date of occurrence of first symptoms. For this purpose, a set of validated questions on symptoms of hand dermatitis (vesicles, scaling, itching, redness, swelling, and fissures) and their frequency and duration was used (23). The type and intensity of exposure during the preceding period was also assessed. For the hairdressers the questions included the frequency of hair washing, giving permanent waves and hair dyeing, the use of gloves, and the type of fluids used for the permanent waves. For the nurses the questions included the frequency of hand washing, washing of patients, use of disinfectants, contact with medica-

ments, treatment of decubitus wounds, use of hand lotion or creams.

2. A physician examined the hands and recorded the presence of signs of (recent) hand dermatitis.

3. Transepidermal water loss was measured on the forearm and the back of the dominant hand according to the same protocol used for the base-line measurements. The results of measurements over time will be reported elsewhere.

Definition of relevant variables

One experienced dermatologist (PJC) identified the cases of hand dermatitis without knowledge of the subjects' base-line characteristics. The diagnosis was based upon the occurrence of symptoms of hand dermatitis during the previous follow-up period as reported in the validated questionnaire (23). The skin findings, as recorded by the physician, were evaluated to exclude mild or doubtful cases or subjects with other skin diseases. Thus a subject was diagnosed as having hand dermatitis if one or more combinations of symptoms, as reported in the questionnaire, had occurred during the previous follow-up period, if the symptoms were recurrent or had lasted for at least three weeks (definition used in validation study), and if this information was supported by the skin findings recorded during the examination of the hands. The date of the onset of symptoms reported in the questionnaire was taken as the incidence date of hand dermatitis.

Information on the history of (atopic) mucosal symptoms was based upon the question "Have you ever suffered from asthma or hay fever?" A history of childhood eczema was based upon the question "Did you suffer from eczema or dermatitis as a child?" The presence of dry skin was assessed by visual scoring, in which a positive score was given when the skin of the hands looked or felt dry or rough.

Patch test readings with a grading of 2+ or more after 72 h were interpreted as positive patch tests. A positive prick test was defined as a reaction (in millimeters) to a test substance that was greater than or equal to the reaction to histamine. Any reaction less than the one to histamine was defined as negative. One or more positive reactions to any of these substances versus all negative tests served as an indicator of the presence of immediate type allergy in the analysis.

The average value of the duplicate measurements of transepidermal water loss was taken as a subject's base-line value for the hand and forearm. For a comparison of the relative risk of high versus low values, boundary points for "high," "intermediate," and "low" were established from each subject's average value according to the tertiles of the distribution of the values in the total study population. Prelimi-

nary analyses showed that the coefficient of variation of the duplicate measurements on a person was 11.7% for transepidermal water loss on the forearm, and the corresponding value was 13.3% for the hand.

Statistical analysis

The incidence rate, expressed as the number of incident cases per 100 person-years of observation, was used as a measure for disease occurrence. Observation time was accumulated from the date of entry into the study to the date of exit from the study. The date of exit was defined as the date of the onset of first symptoms for cases or the date of lost to follow-up or end of the study for noncases. For comparison with results from other studies, the cumulative incidence of hand dermatitis was derived from the incidence rates (24).

The relationship between the variables of interest and the risk of hand dermatitis was assessed by means of Cox proportional hazard models (25). This method makes use of the instantaneous incidence rate ("hazard rate") at each point in time that a subject developed hand dermatitis. The ratio of the hazard rates for subjects with and without the factor of interest (for example, atopic versus nonatopic constitution) is a generic measure of the relative risk of the factor of interest. The term "significant" has been used throughout this paper to refer to statistical significance at the 5% level. The following steps were taken in the analysis.

1. The validity of the proportional hazard assumption was explored for all potential risk factors of interest. The assumption was valid for all such factors. Given the substantial differences in exposure conditions between the hairdressers and nurses, however, separate analyses were initially performed for both groups. An overall relative risk for each factor among the hairdressers and nurses combined was estimated by stratification on the type of training in this analysis, the differences in the base-line hazard rate between the two groups thus being allowed for.

2. The crude and adjusted estimates of the relative risk for each risk factor and its 95% confidence interval were estimated from the regression coefficients of a Cox regression model, modeling each risk factor separately.

Results

Characteristics of the study population

Table 1 shows the base-line characteristics of the 74 hairdressers and 111 nurses who contributed person-time to the study population. Only small differences were observed in the distribution of characteristics between the subgroups of hairdressers and nurses who entered the study population at different times. The study population of apprentice hairdressers was four years younger on the average than apprentice nurses and contained a higher proportion of men. The proportion of self-reported (atopic) mucosal symptoms was higher among the hairdressers than among the nurses, whereas the proportion of sensitized subjects and the proportion of subjects with dry skin were smaller among the hairdressers. The differences in the distribution of the base-line characteristics between the men and women were difficult to interpret due to the small number of men. Nevertheless, gender was taken into account in all of the analyses as a potential confounder. The Pearson correlation coefficient between a history of (atopic) mucosal symptoms and the presence of one or more positive prick tests was 0.46 ($P < 0.001$). Nevertheless, 10% (5 of 50) of the hairdressers and 10% (7 of 70) of the nurses without (atopic) mucosal symptoms showed a positive response to the prick tests, while 53% (8 of 15) of the hairdressers and 50% (5 of 10) of the nurses with a positive history of mucosal symptoms showed a negative response to all of the prick tests. No significant relationship was observed between a history of childhood eczema and the results of the prick or patch tests.

Before the start of the study, 35% of the apprentice hairdressers had been occasionally involved in hairdresser's activities, mainly hair washing and

Table 1. Base-line characteristics of the study population of apprentice hairdressers and nurses.

Study population	Age		Transepidermal water loss (g · m ⁻² · h)				Childhood dermatitis (%)	History of mucosal atopy (%)	Dry skin (%)	One or more positive prick tests (%)	One or more positive patch tests (%)	Positive patch test to nickel (%)
			Hand		Arm							
	Mean	SD	Mean	SD	Mean	SD						
Apprentice hairdressers												
Men (N = 17)	18.8	2.7	9.2	3.2	6.4	2.1	11.8	11.8	5.9	26.7	26.7	13.3
Women (N = 57)	17.6	1.0	8.3	3.4	6.0	1.8	7.0	26.3	7.0	14.6	23.2	14.3
Total (N = 74)	17.9	1.6	8.5	3.3	6.1	1.9	8.1	23.0	6.8	17.1	23.9	14.1
Apprentice nurses												
Men (N = 7)	23.0	1.5	10.6	2.3	6.9	1.4	0	0	14.3	20.0	20.0	0
Women (N = 104)	21.9	1.0	9.7	3.2	6.5	1.5	6.7	12.5	13.5	13.4	33.3	25.6
Total (N = 111)	22.0	2.5	9.8	3.2	6.5	1.5	6.3	11.7	13.5	13.8	32.5	24.1

drying. None of the nurses had been working as a nurse before the start of the study.

The mean transepidermal water loss from the hand of the hairdressers was $1.3 \text{ g} \cdot \text{m}^{-2} \cdot \text{h}$ less than that of the nurses. No difference was observed between the hairdressers and nurses in transepidermal water loss of the forearm. In addition, no significant differences were observed in the base-line characteristics of the subjects with high and low transepidermal water loss. The measurement conditions were different on the six occasions that the base-line measurements were performed. However, the differences in the mean of the transepidermal water loss were not associated with the differences in the measurement conditions.

Incidence of hand dermatitis

Seventeen hairdressers and 16 nurses developed hand dermatitis while they were under observation. In most cases, the symptoms were mild to moderate and occurred periodically. None of the apprentices discontinued their training due to hand dermatitis. However, one hairdresser who was diagnosed as having hand dermatitis during the study consulted the dermatology clinic within six months after she had been professionally employed. The average observation time was 36 weeks for the hairdressers (total of 2691 person-weeks) and 52 weeks for the nurses (total 5747 person-weeks).

The type and intensity of exposure was fairly homogeneous within the study population of hairdressers. Figure 2 shows that the exposure frequency during hair washing, permanent waving, and hair dyeing steadily increased during the practical training. The variation in reported frequencies between persons was small. No association was observed between the exposure characteristics and the point of entry into the study as a hairdresser. The incidence rate was highest for the period between three to six months after the start of training, and it greatly declined thereafter. The average incidence rate was 32.8 cases per 100 person-years of observation for the hairdressers. The one-year cumulative incidence was 27.9%.

For the apprentice nurses, the average incidence rate of hand dermatitis over the total study period was 14.5 cases per 100 person-years of observation (one-year cumulative incidence of 13.5%). The incidence rate was highest during the first two periods of practical training and was lower during periods of classes and during the last period of practical training (figure 3). The difference in incidence rates between the periods was not significant. The average incidence rate in the first school year was 19.8 cases per 100 person-years of observation. In the second year, the average incidence rate was 5.2 cases per 100 person-years of observation. The type and intensity of exposure were more heterogeneous for the apprentice nurses than for the hairdressers. They

depended mainly on the type of institution in which the period of practical work was spent. Hands were washed more frequently in general hospitals and nursing homes (varying from 10 to 40 times per shift on the average) than in institutions for psychiatric patients and for mentally defective patients (less than five times per shift on the average). Differences in the frequency of washing and changing patients were less marked between these two types of institutions; nevertheless, they showed some variation between persons. However, no association was observed between the exposure characteristics of each training period and the presence of endogenous characteristics.

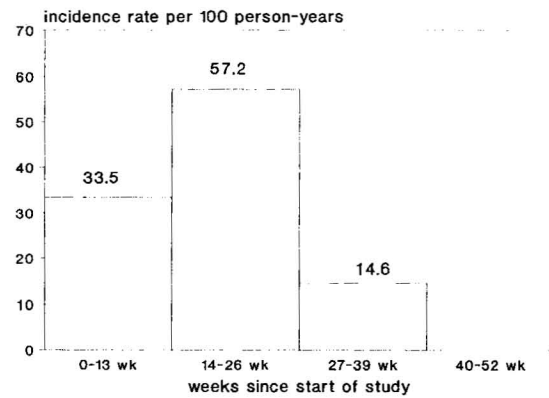


Figure 2. Incidence of hand dermatitis among the hairdressers in relation to the time since the start of the apprenticeship and exposure. (Exposure characteristics: first quarter: hand washing three times a week, giving permanent waves less than once a week, hair dyeing less than once a week; second quarter: hand washing 15–20 times a week, giving permanent waves three times a week, hair dyeing one time a week; third quarter: hand washing 20–30 times a week, giving permanent waves 4–5 times a week, hair dyeing twice a week)

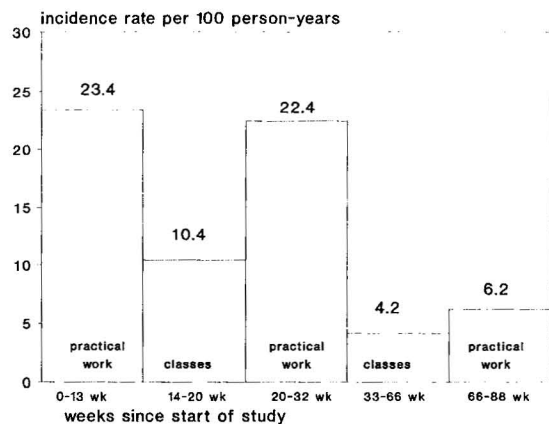


Figure 3. Incidence of hand dermatitis among the nurses in relation to the time since the first period of practical work.

Relation between the base-line characteristics and the incidence rate of hand dermatitis

The crude and adjusted relative risks of developing hand dermatitis are shown in table 2 for the risk factors of interest. Adjustment for mucosal atopy and skin type altered the point estimates of the relative risk to some extent. Other endogenous risk factors (including gender) made no significant contributions to the model, nor did they meaningfully influence the magnitude of the point estimates of these relative risks. When the fact that subgroups entered the study at different times (thus experiencing different sequential effects of the seasons) was taken into account in the analysis, the estimates of the relative risk did not change meaningfully.

The relative risk for hand dermatitis of dry versus normal skin was elevated both for the hairdressers and the nurses; however, the increased relative risk was significant at the 5% level only for the hairdressers. The relative risk of (atopic) mucosal symptoms was elevated for both groups as well, but the increase was significant at the 5% level only for the nurses. The relative risks of skin type and mucosal

atopy differed in magnitude between the hairdressers and nurses, but these differences were not significant at the 5% level. The overall estimates, adjusted for type of training, showed a significant 2.5-fold increased relative risk for mucosal atopy and a significant 3.2-fold increase in the relative risk for dry skin. No significant association was observed between age, gender, childhood eczema, or presence of a positive skin test (prick or patch test) and the risk of hand dermatitis.

The lack of a relationship with transepidermal water loss as a continuous variable indicates that there was no linear increase in the risk of hand dermatitis with increasing transepidermal water loss on the hand or forearm. Adjustment for the temperature and humidity of the ambient air did not alter the estimates of the relative risk. Figure 4 (hairdressers) suggests that, for transepidermal water loss below $15 \text{ g} \cdot \text{m}^{-2} \cdot \text{h}$, there was no clear relationship with the incidence rate, whereas the incidence rate was elevated for transepidermal water loss above $15 \text{ g} \cdot \text{m}^{-2} \cdot \text{h}$. Figure 5 (nurses) provides no evidence for a relationship between transepidermal water loss on

Table 2. Crude and adjusted relative risks for hand dermatitis among the apprentice nurses and hairdressers, 1990–1992. (RR = relative risk, 95% CI = 95% confidence interval)

Variable	Hairdressers			Nurses			Total ^a		
	Crude RR	Adjusted RR ^b	95% CI of the adjusted RR	Crude RR	Adjusted RR ^b	95% CI of the adjusted RR	Crude RR	Adjusted RR ^b	95% CI of the adjusted RR
Gender (men versus women)	1.5	1.1	0.3–4.0	1.1	0.9	0.4–3.3	1.3	1.1	0.4–3.3
Childhood eczema (positive versus negative)	0.6	0.4	0.1–6.8	1.0	1.2	0.1–9.0	0.8	0.7	0.2–3.2
(Atopic) mucosal symptoms (positive versus negative)	1.6	2.2	0.7–6.7	3.1	3.4*	1.05–11.2	2.1	2.5*	1.1–5.7
Skin type (dry versus normal or oily)	5.7*	7.3**	2.2–24.3	1.4	1.7	0.5–6.4	2.6*	3.2**	1.3–7.8
Prick test ^c (one or more positive versus all negative)	1.6	2.2	0.7–7.2	0.6	0.6	0.1–4.9	1.2	1.4	0.5–3.9
Patch test ^c (one or more positive versus all negative)	2.2	1.8 ^d	0.6–5.0	1.5	1.5 ^d	0.5–4.6	1.8	1.7 ^d	0.8–3.6
Patch test to nickel ^c (positive versus negative)	2.4	1.7 ^d	0.5–5.5	1.0	1.1 ^d	0.3–4.0	1.6	1.5 ^d	0.6–3.5
Transepidermal water loss									
Forearm									
Per $\text{g} \cdot \text{m}^{-2} \cdot \text{h}$	1.16	1.19	0.94–1.52	1.07	1.07	0.8–1.44	1.12	1.12	0.93–1.35
Intermediate versus low ^e	1.3	2.4	0.6–9.6	0.5	0.5	0.1–1.9	0.8	0.9	0.4–2.4
High versus low ^e	1.4	2.2	0.7–7.7	1.1	1.2	0.4–4.1	1.3	1.5	0.7–3.4
Hand									
Per $\text{g} \cdot \text{m}^{-2} \cdot \text{h}$	1.14	1.14	0.98–1.29	0.98	0.98	0.84–1.14	1.05	1.05	0.94–1.15
Intermediate versus low ^f	2.2	2.2	0.7–6.9	1.6	2.0	0.5–8.0	1.9	2.1	0.9–5.1
High versus low ^f	1.4	1.6	0.5–5.4	1.5	1.6	0.4–6.4	1.5	1.5	0.6–3.6

^a Combined estimate of rate ratio adjusted for type of training by stratification in the analysis.

^b Relative risk adjusted for dry skin and (atopic) mucosal symptoms.

^c Based on incomplete data set because of missing values on the skin tests.

^d Relative risks adjusted for skin type only, since (atopic) mucosal symptoms correlated highly with the prick test results.

^e Transepidermal water loss: low: less than or equal to $5.5 \text{ g} \cdot \text{m}^{-2} \cdot \text{h}$; intermediate: $>5.5 \leq 6.8 \text{ g} \cdot \text{m}^{-2} \cdot \text{h}$; high: $>6.8 \text{ g} \cdot \text{m}^{-2} \cdot \text{h}$.

^f Transepidermal water loss: low: less than or equal to $7.7 \text{ g} \cdot \text{m}^{-2} \cdot \text{h}$; intermediate: $>7.7 \leq 10.1 \text{ g} \cdot \text{m}^{-2} \cdot \text{h}$; high: $>6.8 \text{ g} \cdot \text{m}^{-2} \cdot \text{h}$.

* $0.01 < P < 0.05$, ** $P \leq 0.01$.

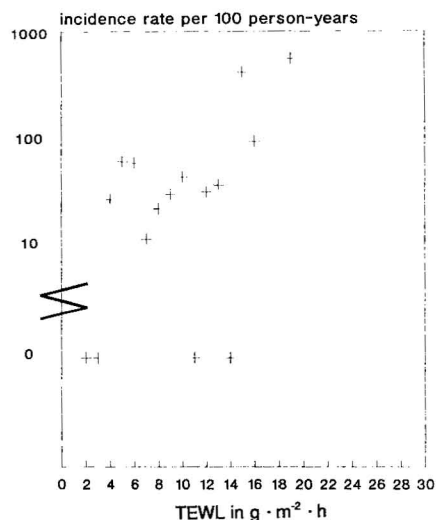


Figure 4. Average incidence of hand dermatitis per gram of transepidermal water loss (TEWL) among the hairdressers in relation to TEWL on the hand.

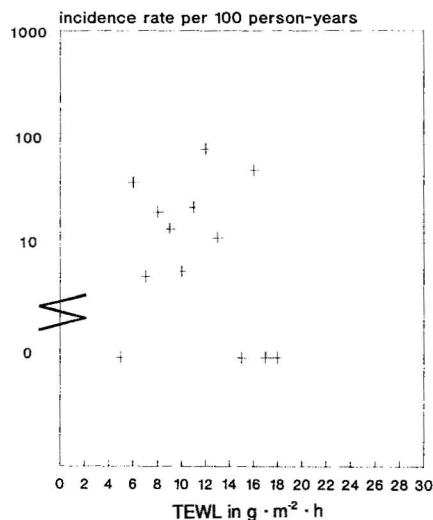


Figure 5. Average incidence of hand dermatitis per gram of transepidermal water loss (TEWL) among the nurses in relation to TEWL on the hand.

the hand and the incidence of hand dermatitis. It should be noted that the average incidence rate in some categories of transepidermal water loss was based on small numbers of subjects.

Discussion

The incidence rate of hand dermatitis was higher for the apprentice hairdressers than for the nurses (32.8 versus 14.5 cases per 100 person-years). It is likely that the differences in the type and intensity of exposure between the hairdressers and the nurses are responsible for the differences in the incidence rates. A previous study among apprentice hairdressers (16) showed that about one-third of the group developed skin changes during the first year of the training. The one-year cumulative incidence of about 28% that was found for the hairdressers in the present study was similar.

The cumulative incidence of hand dermatitis among apprentice nurses over the entire study period of 21 months was 21.8%. The cumulative incidence figures for nurses, as observed in a Swedish (2) and a Dutch (26) study, were 41% (20 months) and 13% (18 months), respectively. The differences are likely to be explained by variations in exposure history and disease status before employment (26).

The presence of dry skin and a positive history of (atopic) mucosal symptoms were associated with the risk of hand dermatitis. Since these characteristics were recorded at the start of apprenticeship, it is unlikely that the association can be explained by information bias. The increased relative risk is unlikely to be attributed to seasonal influences since the subgroups entering the study population at different

times of the year had a similar distribution of endogenous characteristics. In addition, accounting for subgroup in the analysis did not meaningfully alter the estimates of the relative risk. It cannot be excluded that some confounding by occupational exposure occurred; occupational exposure was not accounted for in the analysis since reliable characterization of exposure and changes over time was not possible on the individual level in this study. However, there was no association between exposure characteristics and the presence of dry skin and (atopic) mucosal symptoms. This lack of association suggested that it was unlikely that the increased relative risk was largely influenced by differences in occupational exposure.

The relationship between hand dermatitis and the presence of dry skin was observed in a previous study among hairdressers and bricklayers (8). An experimental study demonstrated that individuals with dry skin react more strongly to exposure to irritants (9). Other studies found that dry skin was a risk factor, particularly in combination with atopic dermatitis (27) or with atopic mucosal symptoms (28). However, dry skin is known to be a diagnostic feature of atopic dermatitis (29). In the present study, skin dryness was not associated with atopic dermatitis or atopic mucosal symptoms, a finding suggesting that atopy cannot explain the association with dry skin. Dry skin may also be an early manifestation of hand dermatitis resulting from previous involvement in wet work, such as household chores, hairdressing, or nursing activities. Although the populations in this study were selected because previous occupational exposure was unlikely, it appeared that 35% of the hairdressers had occasionally been involved in hairdressing activities before the start of the study. Inspection of the data showed that the presence of dry

skin was not associated with previous exposure or with a history of childhood eczema. This finding suggests that dry skin, at least in the present study, represents a risk factor for hand dermatitis *per se*, rather than an early manifestation of hand dermatitis.

The association between (atopic) mucosal symptoms and the risk of hand dermatitis has also been observed in previous studies (5, 30), whereas no association was observed in other studies (3, 4). The biological mechanism explaining the relationship between (atopic) mucosal symptoms and hand dermatitis is not fully understood. In addition, the validity of self-reported atopic mucosal symptoms is unknown. About 50% of the subjects who reported (atopic) mucosal symptoms responded negatively to the prick tests. This finding suggests some overreporting of (atopic) mucosal symptoms, although local allergic reactions may occur in spite of negative skin tests. The absence of an association between hand dermatitis and a positive prick test indicates that the mechanism responsible for an elevated risk of hand dermatitis is more closely related to mucosal symptoms than to an atopic constitution, as determined by prick tests.

The lack of an association with childhood eczema in the present study is inconsistent with results from other studies suggesting that childhood eczema is the most important risk factor for hand dermatitis (3, 4). It is possible that our study lacked the power to detect a potential association, because the study population contained only a small number of persons with childhood eczema. Furthermore, four individuals with atopic dermatitis who showed hand dermatitis at the start of the study were excluded from the analysis. They were examined at each follow-up measurement, and hand dermatitis continued to exist throughout the study.

The risk of hand dermatitis in nickel-sensitive apprentices was not significantly increased. This finding is inconclusive, because it is not clear whether exposure to nickel or other sensitizing agents had occurred in the study population. The absence of a relation between the risk of hand dermatitis and age or gender was in agreement with results from other studies (13, 31).

Finally, the present study does not support the hypothesis that base-line transepidermal water loss is an indicator for the risk of hand dermatitis. The results suggested that hairdressers may have an increased risk of hand dermatitis at transepidermal water loss above $15 \text{ g} \cdot \text{m}^{-2} \cdot \text{h}$ in the hand, but the increased risk was not statistically significant. No evidence of a relationship was observed for the nurses. At present, no other epidemiologic studies are available to refute or confirm the lack of an association between transepidermal water loss and the risk of hand dermatitis. It has been suggested that transepidermal water loss merely reflects the barrier function of the skin for substances with physical and

chemical properties similar to those of water (32), whereas occupational exposure of nurses and hairdressers may involve other types of chemicals as well. The lack of a clear relationship in this study would seem to confirm that suggestion. On the other hand, a true association may have gone undetected due to the small sample size and relatively large interindividual variation in transepidermal water loss. A preliminary study indicated that the intraindividual variability of transepidermal water loss over a period of three weeks was 15.1%, a finding suggesting that transepidermal water loss is relatively stable over that length of time (33). Nevertheless, it is likely that the fluctuations are greater over longer periods (months, seasons, years) and great fluctuations in long-term transepidermal water loss would limit the practical value of this variable as a predictor for the risk of hand dermatitis.

In summary, the incidence of hand dermatitis was increased among the apprentices studied, especially among hairdressers with dry skin. Apprentices with a history of (atopic) mucosal symptoms, particularly nurses, also had an increased risk of hand dermatitis. This relationship has been observed in other studies, but a biological mechanism that could explain this finding is not fully understood. The results of the study do not support the hypothesis that an elevated level of transepidermal water loss increases the risk of hand dermatitis.

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