

Transepidermal water loss and incidence of hand dermatitis in a prospectively followed cohort of apprentice nurses

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The purpose of the study was to evaluate the incidence of hand dermatitis, the impact of potential risk factors and the efficacy of skin bioengineering in a prospectively followed cohort of apprentice nurses. 104 participants were prospectively followed for 3 years. Before the start of training, after about 1 year and in the third year of occupational exposure, a standardized questionnaire was distributed, and a clinical examination with skin bioengineering of the dorsum of hand and forearm was performed. The 12-month period prevalence of self-reported symptoms of hand dermatitis was 36.5% [95%-confidence interval (CI) 27.3–46.6] at intermediate follow-up and 43.3% (95%-CI 33.6–53.3) at the final examination. Apprentices with self-reported symptoms at the final examination showed a significant increase of transepidermal water loss (TEWL) at the dorsal hand from 10.15 g/m²h to 13.55 g/m²h. TEWL at this site did, at the initial examination, not differ significantly between persons who later reported symptoms of hand dermatitis at the final examination and those who did not (10.50 g/m²h versus 10.15 g/m²h, respectively). Our results do not support the notion that an increased basal TEWL is a good indicator for hand dermatitis risk.

Key words: apprentice nurses; epidemiology; health care workers; irritant contact dermatitis; prospective cohort study; skin bioengineering methods; transepidermal water loss.

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Occupational hand dermatitis usually has a multifactorial aetiology with constitutional and exogenous factors contributing (1). There is conflicting evidence regarding individual susceptibility to develop contact dermatitis (2), including the role of atopy (3, 4). Several authors have suggested that baseline pre-exposure transepidermal water loss (TEWL) can serve as an indicator of individual susceptibility to the development of contact dermatitis (5, 6) while others challenged this notion (7, 8).

Irritant contact dermatitis is a well-known occupational hazard for health care workers. Furthermore, irritant damage of the hands increases the risk (i) of subsequent allergic contact dermatitis and (ii) of colonization with potential pathogens. Nurses were chosen as study population, because they are known to be at high risk for the development of hand dermatitis (9–12). However, in senior nurses, aetiological factors are difficult to evaluate, e.g. due to (self) selection in terms of a 'healthy worker effect'. Hence, appren-

tices are the most suitable source of epidemiological data to prospectively evaluate the risk of developing hand eczema (13). This article presents results on the incidence of hand dermatitis, the impact of potential risk factors for the development of skin disease and on the efficacy of skin bioengineering in a prospectively followed cohort of apprentice nurses.

Subjects and Methods

Apprentice nurses

Between October 2000 and October 2001, 148 apprentice nurses started their training at the occupational school of the University Hospital Erlangen-Nuremberg. 139 agreed to participate. Of these, 35 were later lost for several reasons (unavailability at the date of follow-up-investigation, lost interest in the study and left school). None of the dropouts discontinued their training due to hand dermatitis. Only those participants were included in the analyses who

had been present at all 3 examinations (initial examination, intermediate follow-up after about 1 year and final examination in the third year). 104 apprentice nurses could be prospectively followed for a full educational cycle (3 years). Written informed consent was obtained regarding participation, including dermatological examination. The apprentice nurses were 20 years old on average (range 17–41 years) with 89 (85.6%) females.

The initial examination took place during the first weeks of theoretical classes, i.e. immediately before the first period of practical training and irritant exposure in various hospital departments.

Follow-up took place on average 358 days after the initial examination. The final examination was, on average, 888 days after the initial examination.

Questionnaire

The standardized questionnaire included occupational history, past and present skin symptoms including signs and symptoms of skin atopy, history of hand eczema, non-occupational exposures, leisure activities, main tasks at work and questions on occupational exposure and protection habits (frequency of hand washing, use of gloves, disinfectants and use of hand lotion or creams). After about 1 year (follow-up) and in the third year (final examination) of occupational exposure, a self-administered questionnaire developed by Smit et al. (14) was used to determine the incidence of symptoms of hand dermatitis over the preceding period of 12 months. The questions were designed to identify as many potential cases as possible and to exclude only persons definitely free of hand dermatitis.

The following symptoms in the past 12 months had been evaluated:

- (1) Red and swollen hands or fingers
- (2) Red hands or fingers and fissures
- (3) Vesicles on the hand or between the fingers
- (4) Scaling hands or fingers with fissures
- (5) Itching hands or fingers with fissures

A person who answered positively to one or more of the questions was diagnosed as 'persons with symptoms of hand dermatitis'.

Furthermore, the following questions had been asked:

- (1) Did one or more of these symptoms last for more than 3 weeks?
- (2) Did one or more of these symptoms occur more than once?

Persons who answered positively to one of the two questions were diagnosed as 'persons

with recurring or severe symptoms of hand dermatitis'.

Additionally, the apprentice nurses had been asked whether they had suffered from hand eczema in the past year ('self-reported period prevalence of hand eczema').

Skin bioengineering

The investigations took place either in an office at the nurses' school or at the occupational medical centre. The measurements could not be performed under completely standardized circumstances, according to the guidelines (15). As stated by Pinnagoda et al. (15), skin surface temperature should be measured and reported in publications, particularly if ambient room air temperature deviates from 20 to 22°C.

As no air-conditioned rooms were available, room and skin temperatures were documented for each test. A statistical evaluation of the bioengineering parameters was performed only in those persons with skin surface temperatures between 28 and 32°C at all 3 examinations ($n = 68$). The following bioengineering parameters were obtained: TEWL (expressed as grams per square meter per hour) and skin surface hydration (corneometry). The tewameter and corneometer TC 350, Courage & Khazaka electronic, Cologne, Germany was used. Measurements were made at 2 sites: left volar forearm about 12 cm from wrist and dorsum of the left hand.

Clinical investigation

A physical examination of the skin was performed, including hands and forearms, by a dermatologist or a specially trained occupational physician. The physical findings were documented in a standardized form. Because the standardized questionnaire had been administered and filled in before, the investigator was not blind to current history when assessing the skin.

Statistical evaluation

Statistical evaluation was performed using the software-package SPSS 11.01 for windows. The term 'significant' has been used throughout this article to refer to statistical significance at the 5% level. Estimates of disease prevalence were accompanied by exact 95% confidence intervals (CIs) based on the binomial distribution. In view of the exploratory nature of statistical testing in this analysis, no alpha-adjustment techniques to account for the effect of multiple testing were employed.

Results

Demographic profile

79 (76.0%) of the apprentice nurses had pursued vocational activities before apprenticeship (mean duration: 11 months, range 2.5–26 months). Almost all activities had included wet work. 4 persons reported occupational skin complaints before start of the apprenticeship, 3 of these also during subsequent apprenticeship.

In an unadjusted statistical analysis, occupationally related skin complaints before the start of apprenticeship and a history of flexural eczema or hand eczema were identified as the main risk factors for developing hand dermatitis. Because of the relatively small sample size, no multifactorial analysis was performed.

Occupational risk factors

The mean frequency of hand washing was 10 times every day at follow-up and 8 times every day at the time of final examination. Antiseptic hand disinfection liquids were used 20 times every day (mean value, follow-up and final examination). Gloves were used 10 times a day with a mean wearing time of 1.4 h at follow-up and 1.5 h at final examination.

Use of skin care products

84.6% of the apprentices used skin care products at the follow-up and 89.4% at the final examination. Skin care products were mainly applied after the end of work (Table 1). Many of the nurses did not use the products provided free of charge by the employer (Table 1), but preferred their own products for pre- and after-work skin care.

Nurses who reported no symptoms at the final examination used skin care products in 84.7% (follow-up and final examination). Those nurses, however who reported symptoms at final examination had increasingly been using skin care pro-

ducts (84.4% at the follow-up and 95.6% at final examination).

Reported symptoms

The 12-month period prevalence of self-reported symptoms of hand dermatitis was 36.5% (95%-CI: 27.3–46.6) at follow-up and 43.3% (95%-CI: 33.6–53.3) at the final examination. Severe or recurring symptoms in the preceding 12 months, according to our definition given above, were reported by 25.0% of the apprentices at follow-up and in 26.9% at the final examination.

If the question, whether 1 or several of the specified complaints had existed already before the apprenticeship was answered with 'no', the symptoms were classified as 'not pre-existing', i.e., incident (Table 2).

The reported incidence of 'hand eczema' was much lower than the incidence of self-reported symptoms (Table 2).

3 (2.9%) of the apprentices reported complaints after the use of latex gloves at the intermediate follow-up (2 cases of erythema and 1 case of whealing). None of them reported complaints at the final examination. At the final examination, 3 other apprentices reported erythema, 1 of them also itching at the eyes, but no case of allergic rhinitis or asthma occurred.

Mainly for socio-economic reasons, according to anecdotal evidence, apprentices remained at work in spite of (mostly mild to moderate) symptoms of dermatitis. In 12 cases, symptoms of hand dermatitis improved during the observation period, which may be attributed to hardening or reduced frequency of hand washing and use of hand disinfectants (Table 3). 19 apprentices reported symptoms for the first time at the final examination. Those apprentices had reduced the frequency of hand washing, enhanced the frequency of hand disinfection and improved the use of skin care products (Table 3).

Table 1. Protection habits of the apprentice nurses and origin of the ointments in those apprentices, who use skin care products

Use of skin care products (in general)		Follow-up 84.6%; n = 88	Final examination 89.4%; n = 93
Use of skin care products before start of the work	In general	59.6%; n = 62	59.6%; n = 62
	Products of the employer	n = 24	n = 23
	Personally bought products	n = 38	n = 39
Use of skin care products during work	In general	59.6%; n = 62	65.4%; n = 68
	Products of the employer	n = 56	n = 59
	Personally bought products	n = 6	n = 9
Use of skin care products after the end of the work	In general	77.9%; n = 81	76.9%; n = 80
	Products of the employer	n = 17	n = 15
	Personally bought products	n = 64	n = 65

Table 2. Reported skin problems at the follow-up and at the final examination (exact 95%-confidence interval)

	Symptoms	Symptoms not pre-existing	Severe or recurring symptoms	Severe or recurring symptoms not pre-existing	Self-reported incidence of hand eczema	Symptoms after the use of latex gloves
Follow-up	36.5% (27.3–46.6)	25.0% (17.0–34.4)	25.0% (17.0–34.4)	13.5% (7.6–21.5)	6.7% (2.7–13.4)	2.9% (0.6–8.2)
Final examination	43.3% (33.6–53.3)	30.8% (22.1–40.6)	26.9% (18.7–36.5)	17.3% (9.8–24.9)	4.8% (1.6–10.9)	2.9% (0.6–8.2)

One suspected case of occupational skin disease was formally reported to the occupational accident insurance.

Skin bioengineering

A statistical evaluation of the bioengineering parameters was performed only in those persons with skin surface temperatures between 28 and 32°C at the 3 examination time points ($n = 68$). TEWL of the dorsal hand varied significantly within the course of vocational training ($P = 0.002$, Friedman test; $n = 68$; Fig. 1). Wilcoxon tests showed a significant difference between initial examination and intermediate follow-up and between initial examination and final examination but not between intermediate follow-up and final examination.

In contrast, TEWL of the forearm did not change significantly. In apprentices without self-reported symptoms at final examination, no significant change of the TEWL of dorsum of hand occurred ($n = 36$). However, the apprentices with symptoms at the final examination showed a significant increase of TEWL of dorsum of hand from 10.15 g/m²h to 13.55 g/m²h ($P = 0.008$; Friedman test, $n = 32$). Wilcoxon test showed a significant difference only between initial examination and intermediate follow up.

In those apprentices who reported severe or recurring symptoms, an increase in TEWL of dorsum of hand was seen from 11.60 g/m²h to 14.40 g/m²h (n.s., Friedman test, $n = 21$).

TEWL of dorsal hands at the initial examination did not differ significantly between persons

who reported symptoms of hand dermatitis at the final examination and those who didn't (10.50 g/m²h versus 10.15 g/m²h, respectively, Mann–Whitney U -test $P = 0.555$). However, a significant difference was seen at the final examination (10.70 g/m²h versus 13.55 g/m²h, respectively, Mann–Whitney U -test $P = 0.032$), but not at intermediate follow-up (11.65 g/m²h versus 13.05 g/m²h, respectively, Mann–Whitney U -test $P = 0.053$).

Concerning corneometry, no consistent, statistically significant effects could be seen in the course of follow-up. This was also true in the group of apprentices with symptoms of hand dermatitis.

Physical examination

The point prevalence of mild to moderate signs of hand dermatitis was 21.2% (95%-CI 13.8–30.3) at the initial examination, 25.0% (95%-CI 17.0–34.4) at the follow-up and 36.5% (95%-CI 27.3–46.6) at the final examination. At each of these occasions, a significant association between findings and self-reported symptoms was observed (chi square test).

Leisure activities

Leisure activities and non-occupational exposures, e.g. dish washing, cleaning, gardening, were documented at all examination time points. For each investigation, a score was calculated from the data about the frequency. No significant changes occurred in the course of the study. Furthermore, no consistent pattern of association was seen between non-occupational exposures and

Table 3. Occupational risk factors and use of skin care products depending on reported symptoms at the follow-up and final examination

	Follow-up–/ final examination–	Follow-up–/ final examination+	Follow-up+/ final examination–	Follow-up+/ final examination+
<i>n</i>	47	19	12	26
Mean frequency of hand washing	10.0/9.0	9.0/7.0	7.0/6.5	10.0/8.0
Mean frequency of antiseptic hand disinfection	20.0/20.0	20.0/25.0	20.0/9.0	25.0/23.5
Mean wearing time of gloves (hours)	1.1/1.0	1.0/1.0	0.5/0.5	1.0/1.5
Use of skin care products (%)	80.9%/80.9%	84.2%/94.7%	100%/100%	84.6%/96.2%

– = no symptoms of hand dermatitis; + = symptoms of hand dermatitis.

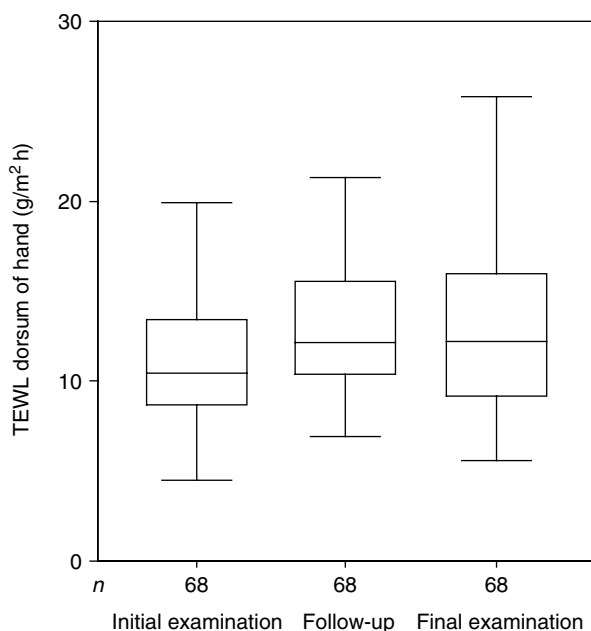


Fig. 1. Transepidermal water loss (TEWL) dorsum of hand (total group). Outliers and extreme values are not presented. Initial examination: 4 outliers, 1 extreme value. Follow-up: 3 outliers, 4 extreme values. Final examination: 2 outliers, 1 extreme value.

the occurrence of symptoms of hand dermatitis or the incidence of clinical signs of hand dermatitis.

Seasonal aspects

Exposure of the hands to a cold environment is a well-known cause of irritant skin changes. Therefore environmental factors must be considered as possible confounders in epidemiological studies (16). Skin bioengineering parameters were measured either in springtime (April, May) or in autumn (October, November). The seasons during which the measurements were performed were not associated with hand dermatitis status.

Discussion

For targeted preventive efforts, the identification of susceptible persons with a high risk of hand dermatitis is desirable. As TEWL correlates with the barrier function of stratum corneum, it could serve either as a predictive parameter, or it could be used to sensitively identify early, subclinical irritant skin damage in patients prone to dermatitis (8). TEWL is apparently independent of the clinical manifestations of atopy (17, 18).

The apprenticeship of our study sample of nurses consisted of different sections with classes and practical training in very different hospital departments. In view of the potentially fluctuating course of hand dermatitis, we considered

1-year prevalence of hand dermatitis as outcome. Self-reported incidence of 'hand eczema' declined during the course and was much lower than the incidence of self-reported symptoms by means of a symptom-based questionnaire (Table 2). An explanation for this finding might be that apprentices increasingly regard skin irritation in the course of the training as a 'natural phenomenon', changing their implicit definition of 'hand eczema'. To sensitively identify persons with hand dermatitis, we therefore used a symptom-based definition covering a 12-month period prevalence designed by Smit et al. (14) in a German translation. Even if a medical evaluation by a trained physician is generally considered as 'gold standard', one medical examination, yielding a point prevalence estimate, is not able to recognize skin symptoms occurring during individual training periods.

A symptom-based questionnaire is a very sensitive instrument, potentially overestimating the incidence of hand dermatitis. Despite this, our investigation showed a clear relation between the occurrence of skin problems in the process of the training and an increase in TEWL at the hands but not at the forearms. We could demonstrate that TEWL of the dorsal hand increases in persons who report (even mostly moderate) symptoms of hand dermatitis.

Reduction of the exposure to skin irritants contributes to the prevention of occupational skin disease in nurses (19). In some cases, symptoms of hand dermatitis improved during the observation period, which may be attributed to a reduced frequency of hand washing and use of hand disinfectants. However, those apprentices who reported symptoms for the first time at the final examination, had reduced the average frequency of hand washing, increased the frequency of hand disinfection and improved the use of skin care products. It is, however, notoriously difficult to conclude whether such changes in behaviour are the cause or the consequence of skin problems, even in longitudinal studies like ours.

Hence, monitoring of TEWL, only in the occupationally primarily exposed area (dorsum of hand) may become useful in the secondary prevention of occupational dermatitis (8, 20). While the subtle response of the cutaneous barrier as monitored with TEWL measurements is associated with the clinical course of hand dermatitis, baseline (pre-exposure) TEWL was not a predictor for the development of contact dermatitis, similar to findings reported by other authors (7, 8, 21).

Especially at the dorsum of hand, we found a relatively large interindividual variation in TEWL

(Figs 1 and 2). The values showed high variability especially among persons with symptoms of hand dermatitis (Fig. 2). Therefore, TEWL cutoff levels to reliably discriminate diseased from healthy individuals cannot be defined.

Measurement of TEWL requires standardized conditions, most favourably an air-conditioned laboratory. However, such requirements are hard to fulfil in field studies, and the routine use in occupational medical surveillance is therefore difficult. In fact, despite restricting the analysis of bioengineering results to a subset of persons with a narrow, acceptable range of skin temperature, measurement conditions may have contributed to the overall variability of TEWL results. Regarding pre-exposure point measurements, the prognostic value of a single measurement becomes even more questionable, in view of large measurement variability.

For these reasons, pre-employment bioengineering should not be used for pre-employment selection, because it is not useful to identify persons at risk for hand dermatitis.

Conclusions

Our results do not support the notion that an increased basal TEWL indicates an elevated risk for developing dermatitis.

In contrast, irritant work exposures may be regarded as a continuous, albeit non-homogenous and non-standardized, moderate irritation test,

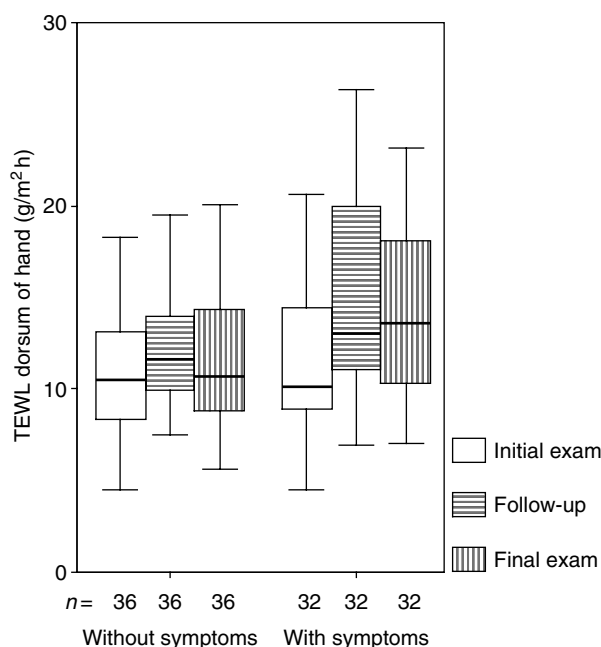


Fig. 2. Transepidermal water loss (TEWL) dorsum of hand (persons with and without symptoms at the final examination). Outliers and extreme values are not presented.

allowing to evaluate the delta-TEWL. This could be demonstrated in our study comparing primarily exposed (dorsum of hand) and much less exposed skin areas (forearm). Therefore, the repetitive measurement of TEWL at selected exposed areas may be important for early detection of subclinical skin irritation. This, in turn, should trigger increased preventive efforts for the affected individuals, such as lessening the load of irritant or occlusive work exposures and non-occupational irritation. However, it must be pointed out that TEWL cut-off levels to reliably discriminate diseased from healthy individuals cannot be defined, and measurement of TEWL requires standardized conditions, which are hard to fulfil in routine occupational medical surveillance.

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