Determinants of hand dermatitis, urticaria and loss of skin barrier function in professional cleaners in New Zealand

Jeroen Douwes^a, Tania Slater^a , Mathangi Shanthakumar^a , Dave McLean^a, Ridvan Tua Firestone^a, Lissa Judd^b and Neil Pearce^{a,c}

^aCentre for Public Health Research, Massey University, Wellington, New Zealand; ^bAnwyl Specialist Medical Centre, Wellington, New Zealand;

^cDepartment of Medical Statistics, London School of Hygiene and Tropical Medicine, London, UK

ABSTRACT

This study assessed the risk of dermatitis, urticaria and loss of skin barrier function in 425 cleaners and 281 reference workers (retail workers and bus drivers). Symptoms, atopy and skin barrier function were assessed by questionnaire, skin prick tests, and measurement of transepidermal water loss. Cleaners had an increased risk of current (past 3 months) hand/arm dermatitis (14.8% vs. 10.0%; OR = 1.9, $p < 0.05$) and urticaria (11% vs. 5.3%; OR = 2.4, $p < 0.05$) and were more likely to have dermatitis as adults (17.6% vs. 11.4%; OR = 1.8, $p < 0.05$). The risk of atopy was not increased, but associations with symptoms were more pronounced in atopics. Transepidermal water loss was significantly higher in cleaners. Wet-work was a significant risk factor for dermatitis and hand washing and drying significantly reduced the risk of urticaria. In conclusion, cleaners have an increased risk of hand/arm dermatitis, urticaria and loss of skin barrier function.

ARTICLE HISTORY

Received 3 August 2016

Accepted 5 January 2018

KEYWORDS

Dermatitis; urticaria; cleaners; transepidermal water loss; risk factors

Introduction

Occupational dermatitis is one of the most common work-related illnesses, and has been estimated to account for approximately 30% of the total burden of occupational disease [1,2]. Although not life-threatening, morbidity is substantial as demonstrated in two longitudinal studies following patients for 8–15 years, showing high frequency of medical consultations and sick leave, and negative psychosocial consequences [3–5]. Occupational dermatitis may also develop into a chronic condition resulting in exclusion from the labour market, through unemployment or disability, in a significant proportion of workers [4–7], associated with high social and economic cost [8]. Atopy has been shown to be the strongest risk factor for poor prognosis of hand dermatitis [4].

Workers in the cleaning industry, which is a large fraction of the workforce globally [9], are frequently exposed to soaps, disinfectants, scouring powders, wax removers and strippers, solvents and drain cleaners, and are believed to have a particularly high risk of occupational hand dermatitis [1,10,11]. This is likely due to the combination of wet work, exposure to surface-active chemicals resulting in impaired skin barrier function causing irritation and inflammation, as well as increased mechanical stress and the occlusion of the skin by wearing gloves [12,13]. In Denmark, cleaners have the highest incidence of notified occupational skin diseases with 13.2 cases per 1000 per year [1], and epidemiological

studies in other countries have also shown an elevated risk of dermatitis in cleaners [14–19]. However, studies on specific risk and protective factors are scant, they have not assessed the risk of urticaria, and none have included objective measures of skin barrier function. Furthermore, the recent emergence of new cleaning technologies including sprays, electrostatic dry cloths, and wet disposable cloths [20] has, at least partially, replaced conventional wet cleaning methods and may have affected dermatitis risk.

The aims of this study were to assess: (1) the prevalence and risk of occupational dermatitis and urticaria in cleaners and its association with work-related risk factors; (2) localised effects on skin barrier function using hand and forearm (exposed) and upper arm (non-exposed) transepidermal water loss measurements; and (3) whether the effects of cleaning on skin symptoms are modified by atopy.

Methods

Study population

Work-related hand and arm dermatitis was assessed in 425 cleaners involved in cleaning hospitals, tertiary education institutions, schools, and commercial buildings. Participants were recruited through the Service and Food Workers Union (SFWU), which represents most workers in the cleaning industry in New Zealand, and

through organisations that employ or contract cleaners. The comparison group was recruited from the same geographical areas and comprised 201 retail/service workers (i.e. people who work in the “shop front” or the storeroom in supermarkets and other retail outlets) and 80 bus drivers. The response rates for cleaners and the reference population were 74 and 34%, respectively. The study was approved by the Massey University Ethics Committee: Southern A, Application 07/29.

Interviews

Questionnaires based on the Nordic Occupational Skin Questionnaire (NOSQ-2002) [21] were administered face-to-face. Dermatitis was defined as self-reported “eczema on hand, wrist or forearm” (ever, in the past 7 days, 7 days–3 months, 3–12 months, or more than 12 months ago). In addition to hand and arm dermatitis (a known risk for professional cleaners – see above) we also assessed urticaria. Although urticaria has not previously been reported to be associated with professional cleaning, some cleaners in New Zealand had previously indicated that they experienced skin symptoms that resembled urticaria. For that reason we also assessed hand and arm urticaria symptoms using the same NOSQ 2002 questionnaire. Urticaria was defined as self-reported “itchy wheals (round, itchy spots) appearing and disappearing rapidly (within hours) on hand, wrist or forearm” (ever, in the past 7 days, 7 days–3 months, 3–12 months, or more than 12 months ago). We defined “current dermatitis” and “current urticaria” as having had dermatitis or urticaria symptoms in the past 3 months, respectively. We also asked when subjects first experienced hand/wrist/forearm dermatitis and urticaria (<6 years, 6–14 years, 15–18 years and >18 years of age). In addition to questions on skin symptoms on hands, wrists and arms the questionnaire also included questions about relevant exposures including hand washing and drying, specific cleaning activities, use of specific cleaning products, use of gloves and skin care products, and potential confounders such as ethnicity, age, and smoking. Questions were framed as occurrences on “a usual working day” e.g. “How many times do you wash your hands during a usual working day? (0–5 times/day, 6–10 times/day, 11–20 times/day, >20 times/day).”

Trans-epidermal water loss

Skin barrier function was assessed by measuring trans-epidermal water loss (TEWL) using the Dermal Measurement System EDS12 (EnviroDerm Services, Evesham, U.K.). Results are expressed in g/m²/h. Measurements were taken on the back of the hand and the top and volar surface on the forearm according to published guidelines [22]. The skin on which the measurements were taken was cleaned with plain wipes and water and the skin was allowed to dry and acclimatise

for at least 15 min. All measurements were taken at room temperature close to 20 °C on healthy skin that was, upon visual examination, not directly affected by dermatitis and/or urticaria. We also took measurements on the upper arm (which was not exposed) applying the same methods to use as a reference estimate of the intrinsic skin barrier function not affected by occupational exposures. All measurements were conducted on the hand/arm that the subjects indicated they used for writing. Due to field work commencing prior to the TEWL device being available we obtained TEWL data for “only” 289 cleaners and 273 reference workers. TEWL data followed an approximately normal distribution; hence subsequent analyses were conducted on non-transformed data.

Atopy

Atopy was assessed using skin prick tests, which were carried out after the TEWL measurements as previously described [23]. Briefly, the volar surface of the forearm was cleaned with alcohol and solutions containing the following aeroallergens were tested: positive control (histamine), negative control (diluent), cat, dog, grass mix, *Alternaria*, *Cladosporium*, *Penicillium*, and house dust mite (Hollister-Stier Laboratories, Spokane, WA, U.S.A.). All tests were read at 15 min. A positive reaction was defined as a wheal with a mean diameter ≥ 3 mm, once any reaction to the negative control had been subtracted. Atopy was defined as having at least one positive skin prick test to any of the common allergen extracts.

Data analyses

For all analyses involving dichotomous outcomes (yes/no), prevalence odds ratios were calculated with the Mantel-Haenszel method [24] and multiple logistic regression adjusting for potential confounders (smoking, age, sex, ethnicity). For the continuous outcome variable (i.e. transepidermal water loss) we conducted multiple linear regression analyses adjusting for the same confounders.

Analyses on work-related risk factors and current dermatitis and urticaria were initially conducted for one exposure variable at a time, adjusted for smoking, age, sex and ethnicity (Model 1). We also assessed associations with “host factors” (i.e. atopy, TEWL and childhood dermatitis and urticaria) using the same approach (Model 1). We subsequently conducted multiple logistic regression models including multiple exposure variables by adding one variable at a time, commencing with the main exposures (i.e. those previously identified as risk factors in other studies) followed by potential confounders that showed the strongest effects (i.e. $p < 0.1$ and/or ORs < 0.5 and/or OR > 2) in the initial analyses (Model 1.1) [25]. At each step, odds ratios were checked for signs of confounding, and standard errors

for signs of multicollinearity. We subsequently applied a full model with all exposure variables included (Model 2). The results of Model 2 were similar to that of the more restricted model (Model 1.1), but Model 2 adjusted for more confounders without apparently introducing multicollinearity. Therefore, results for Model 1.1 are not shown. Finally, we applied a full model (similar to Model 2) with additional adjustment (Model 3) for those host factors that were significantly associated with current dermatitis and urticaria in initial analyses (Model 1), which was the case only for childhood dermatitis and urticaria.

Results

Compared with the reference group, cleaners had a higher proportion of women, Māori and Pacific people; they also smoked more and were older (Table 1). All analyses were therefore controlled for age, sex, ethnicity and smoking. The majority of cleaners were involved in cleaning residential or commercial buildings, hospitals and pharmacies; a smaller proportion was involved in cleaning cafes/restaurants/kitchens and industrial settings (mostly meat works; Table 1). The most common

cleaning activities included: dusting, sweeping, vacuuming, mopping, wet cleaning, damp wiping, cleaning toilets, and cleaning windows or mirrors. Almost 50% of the reference workers also undertook cleaning activities, but the frequency of these activities was relatively low and was considerably less than those reported by the cleaners (Table 1; shown for work-related cleaning activities conducted ≥ 4 days/wk). Also, the time spent on each cleaning activity was considerably less for reference workers. For example, only 20% of reference workers involved in dusting/sweeping/vacuuming ≥ 4 days/week did this for more than 1 h/day vs. 78% of cleaners; the equivalent percentages for mopping/wet cleaning/damp wiping were 16 and 71%, respectively.

Cleaners were more likely to report current (within the past 3 months) hand/arm dermatitis (14.8% vs. 10.0%; OR 1.9; 95%CI 1.1, 3.2) and develop hand/arm dermatitis in adult life (17.6% vs. 11.4%; OR 1.8; 95%CI 1.1, 2.9; Table 2). They also more frequently visited a doctor as an adult for hand, wrist or forearm dermatitis (OR 1.50; 95%CI 0.9, 2.5), but this did not reach statistical significance (Table 2). Cleaners also had an increased risk of current hand/arm urticaria (OR = 2.4; 95%CI 1.2, 4.6) and hand/arm urticaria after the age of

Table 1. Demographic and work characteristics for cleaners and reference workers.

	Cleaners (<i>n</i> = 425)		Reference (<i>n</i> = 281)		Difference <i>p</i>
	<i>n</i>	%	<i>n</i>	%	
Sex					<0.0001
Males	97	22.8	142	50.5	
Females	328	77.2	139	49.5	
Ethnicity					<0.0001
New Zealand European	141	33.2	189	67.5	
Māori	114	26.8	38	13.6	
Pacific	118	27.8	29	10.4	
Other	49	11.5	24	8.6	
Ethnicity (dichotomised)					<0.0001
Māori/Pacific	232	54.6	67	23.8	
Non-Māori/Non-Pacific	190	44.7	213	75.8	
Smoking history					0.9895
Current smoker	178	41.9	81	28.9	
Ex-smoker	59	13.9	75	26.8	
Non-smoker	188	44.2	124	44.3	
Current smoking (dichotomised)					0.0004
Current smoker	178	41.9	81	28.8	
Ex-smoker/non-smoker	247	58.1	199	70.8	
Cleaning activities at work ≥ 4 days/wk					
Dusting/sweeping/vacuuming	300	71.2	30	10.7	<0.0001
Mopping/wet cleaning/damp wiping	341	81.0	49	17.5	<0.0001
Cleaning toilets	287	68.2	2	0.0	<0.0001
Polishing, waxing, shampooing	41	9.7	0	0.0	<0.0001
Cleaning windows/mirrors	241	57.2	15	5.4	<0.0001
Cleaning the kitchen	205	48.7	20	7.1	<0.0001
Washing/soaking clothes/linen by hand	20	4.8	0	0.0	0.0002
Washing clothes by machine	37	8.8	3	1.1	<0.0001
Cleaning machinery in industrial setting	55	13.1	10	3.6	<0.0001
Type of cleaning work ^a					
Homes/schools/offices/shops/hotels	328	52.5	–	–	
Hospitals/pharmacies	138	22.1	–	–	
Industrial	75	12.0	–	–	
Café/Restaurant/Kitchens	63	10.1	–	–	
Outside	21	3.4	–	–	
	Mean	SD	Mean	SD	
Age	45	12.9	40	15.1	<0.0001
Years worked in current job (yrs)	8.5	8.6	6.2	7.13	0.0001
Number of hrs/wk working as a cleaner	33.8	12.1	–	–	

^aCleaners were often involved in multiple types of cleaning work hence the combined number of cleaners listed for each type of cleaning exceeded 425.

Table 2. Hand/wrist/forearm dermatitis and urticaria on hand, wrist or arm in cleaners and reference workers.

Symptom	Cleaners (n = 425)		Reference (n = 281)		OR (95% CI) ^a
	n	%	n	%	
Dermatitis					
Hand/arm eczema ever (y/n)	106	25.2	64	22.9	1.2 (0.8–1.7)
≥1 area affected (y/n)	102	24.0	61	21.7	1.2 (0.8–1.8)
Last had hand/arm eczema					
past 7 days	43	10.1	19	6.8	1.9 (1.1–3.2)*
7 days–3 months ago	20	4.7	9	3.2	(<3 months vs. >3 months or never)
3–12 months ago	14	3.3	10	3.6	
>12 months ago	26	6.1	24	8.5	
Age when first had hand/arm eczema					
<6 years	11	2.6	14	5.0	1.8 (1.1–2.9)*
6–14 years	12	2.8	8	2.8	(>18 yrs vs. <18 or never)
15–18 years	5	1.2	9	3.2	
>18 years	75	17.6	32	11.4	
Seen doctor as adult for hand/arm eczema (y/n)	59	13.9	30	10.7	1.5 (0.9–2.5)
Hand/arm eczema improves when away from work					
Usually	42	9.9	15	5.3	2.5(1.4–4.4)**
Sometimes	20	4.7	6	2.1	(yes vs. no)
Urticaria					
Hand/arm itchy wheals ever (y/n)	100	23.5	47	16.7	1.3 (0.9–2.0)
Last had hand/arm itchy wheals					
past 7 days	24	5.6	6	2.1	2.4 (1.2–4.6)**
7 days–3 months ago	23	5.4	9	3.2	(<3 months vs. >3 months or never)
3–12 months ago	22	5.2	12	4.3	
>12 months ago	31	7.3	20	7.1	
Age when first had hand/arm itchy wheals					
<6 years	4	0.9	7	2.5	1.7 (1.0–3.0)
6–14 years	23	5.4	11	3.9	(>18 yrs vs. <18 yrs or never)
15–18 years	9	2.1	8	2.8	
>18 years	64	15.1	21	7.5	
Seen doctor as adult for hand/arm itchy wheals (y/n)	38	8.9	6	2.1	3.6 (1.4–9.1)**
Hand/arm skin symptoms and glove use					
Symptoms due to gloves (y/n)	103	24.2	19	6.8	3.9 (2.2–6.7)**
Changed glove type or stopped using gloves due to symptoms (y/n)	51	12.0	5	1.8	6.8 (2.6–17.9)**

^aAdjusted for age, sex, ethnicity, smoking.**p* < 0.05; ***p* < 0.01.

18 (not statistically significant) and to see a doctor as an adult for urticaria (OR = 3.6; 95%CI 1.4, 9.1). Also, in cleaners hand/arm dermatitis was 2.5 times (OR 2.5; 95%CI 1.4, 4.4) more likely to improve when away from work. Of interest, one in four cleaners (24.2%) reported skin symptoms (not further specified) due to the use of gloves and 12% had changed glove type or stopped using gloves due to skin symptoms on hands, wrists or arms (Table 2).

Cleaners had a slightly reduced risk of atopy (OR = 0.8; 0.6, 1.1; Table 3). Analyses comparing cleaners and reference workers stratified by atopy showed that associations with cleaning were somewhat more pronounced in atopic workers. The greatest differences were observed for hand/arm eczema developed after the age of 18 years (OR 2.2; 95%CI 1.1, 4.2 in atopics vs. OR 1.4; 95%CI 0.7, 1.9 in non-atopics), current hand/arm urticaria or itchy wheals (OR 3.2; 95%CL, 1.3, 8.2 vs. OR 2.2; 95%CI 0.8, 5.7), seen doctor as adult for hand/arm urticaria (OR 7.0; 95%CI 1.5, 32.3 vs. OR 2.1; 95%CI 0.7, 7.0), symptoms due to gloves (OR 4.4, 95%CI 2.0, 9.6 vs. OR 3.1; 95%CI 1.4, 7.0) and having changed glove type or stopped using gloves due to symptoms (OR = 21.9; 95CI 2.8, 171.5 vs. OR = 2.9; 95%CI 0.9, 9.0).

TEWL on the hand and forearm was significantly elevated (15.5 and 17.9% respectively) in cleaners

Table 3. Atopic sensitisation in cleaners and the reference group.

Allergen ^b	Cleaners (n = 417)		Reference group (n = 278)		OR (95% CI) ^a
	n	%	n	%	
Grass mix	99	23.7	74	26.6	0.8 (0.5–1.2)
HD Mite	175	42.0	120	43.2	0.9 (0.6–1.3)
Tree Mix	40	9.6	31	11.2	0.8 (0.5–1.4)
Cat	41	9.8	41	14.7	0.5 (0.3–0.9)*
Dog	18	4.3	14	5.0	1.0 (0.4–2.1)
<i>Alternaria</i>	23	5.5	17	6.1	0.9 (0.5–1.9)
<i>Cladosporium</i>	17	4.1	9	3.2	0.9 (0.4–2.4)
<i>Penicillium</i>	10	2.4	12	4.3	0.5 (0.2–1.2)
Atopy ^c	212	50.8	153	56.6	0.8 (0.6–1.1)

^aAdjusted for age, sex, ethnicity, smoking.^bA positive response is defined as a wheal with a mean diameter of greater than or equal to 3 mm, once any reaction to the negative control has been subtracted.^cAtopy is defined as at least one positive skin prick test to any of the common allergen extracts.**p* < 0.05.

compared to the reference group (Table 4) whereas no difference in TEWL on the upper arm (which is typically not exposed) was found. No significant associations between TEWL and skin symptoms were found in cleaners (Table 5; shown for TEWL at the back of the hand and volar forearm). In contrast, TEWL in reference workers was significantly associated with current hand/arm dermatitis for TEWL measured at the back of

Table 4. Trans-epidermal water loss (TEWL) in cleaners and reference workers.

Location of TEWL measurement	Cleaners <i>n</i> = 289		Reference <i>n</i> = 273		Difference ^a
	Mean TEWL ^b	SD	Mean TEWL ^b	SD	
Back of hand	7.8	3.7	6.9	2.9	1.0 (0.5 – 1.7)**
Top forearm	7.1	3.1	6.7	2.1	0.5 (0.0 – 1.0)*
Volar forearm	7.8	3.2	6.8	2.3	1.2 (0.7 – 1.7)**
Upper arm	7.3	2.8	7.6	4.8	0.0 (–0.7 – 0.7)

^aAdjusted for age, sex, ethnicity, smoking.^bUnit: g/m²/h.**p* < 0.05; ***p* < 0.01.**Table 5.** Associations between hand/arm skin symptoms and trans-epidermal water loss (TEWL) in cleaners and reference workers.

	Trans-epidermal water loss (TEWL) [†]	
	Back of hand	Volar forearm
	Difference ^a	
	Mean TEWL ^b (95% CI)	Mean TEWL ^b (95% CI)
Symptoms (y/n) for Cleaners (<i>n</i> = 289)		
Eczema in the past 3 months	0.5 (–0.7 – 1.7)	–0.3 (–1.3 – 0.7)
Eczema at age >18 yrs	0.3 (–0.8 – 1.4)	–0.4 (–1.4 – 0.5)
See doctor for eczema as adult	0.1 (–1.2 – 1.3)	–0.3 (–1.3 – 0.8)
Itchy wheels in the past 3 months	–0.9 (–2.3 – 0.6)	–0.1 (–1.3 – 1.2)
Itchy wheels at age >18 yrs	–0.6 (–1.8 – 0.6)	–0.9 (–1.9 – 0.1)
Seen doctor for itchy wheels as adult	–0.6 (–2.2 – 1.0)	–0.2 (–1.5 – 1.2)
Symptoms (y/n) for reference group (<i>n</i> = 278)		
Eczema in the past 3 months	1.7 (0.5 – 2.8)**	0.7 (–0.2 – 1.5)
Eczema at age >18 yrs	1.0 (–0.0 – 2.1)#	0.1 (–0.7 – 0.9)
See doctor for eczema as adult	0.7 (–0.4 – 1.8)	0.3 (–0.6 – 1.1)
Itchy wheels in the past 3 months	–0.7 (–2.2 – 0.8)	–0.1 (–1.2 – 1.1)
Itchy wheels at age >18 yrs	–0.8 (–2.1 – 0.5)	–1.0 (–2.0 – –0.0)**
Seen doctor for itchy wheels as adult	–2.5 (–4.7 – –0.2)*	–1.8 (–3.5 – 0.0)*

^aAdjusted for age, sex, ethnicity, smoking.^bUnit: g/m²/h.#*p* < 0.1**p* < 0.05; ***p* < 0.01.[†]For brevity only TEWL results for back of hand and volar forearm are shown.

the hand; a borderline significant association was also found for hand/arm dermatitis at age >18 years (Table 5). Urticaria was *inversely* associated with TEWL for both hand and volar forearm, but this was statistically significant only for the reference group and for urticaria at age >18 years and urticaria seen by a doctor as an adult (Table 5). No association was found between atopy and TEWL (data not shown).

Hand exposure to water (without wearing gloves) was strongly associated in a dose-dependent fashion (*p* < 0.05 for trend; Table 6) with current hand/arm dermatitis after controlling for other occupational risk factors. In particular, compared to no exposure, those who were exposed for 2–5 h/day and >5 h had an approximately

5 (OR 4.6; 95%CI 1.2, 18.3) and 7 (OR 6.6; 95%CI 1.2, 37.2) times higher risk, respectively (Table 6; Model 2); exposures of <1/2 an hour and <2 h were associated with an approximately 3 times higher risk (OR 2.6; 95%CI 1.2, 6.0 and OR 2.9; 95%CI 1.0, 8.1, respectively). Further adjustment for childhood dermatitis strengthened these associations (Table 6, Model 3). The use of solvents and stain removers was positively associated with hand/arm dermatitis, which was statistically significant when analyses were adjusted for childhood dermatitis (Model 3; OR 3.1; 95%CI 1.1, 8.7) and borderline statistically significant for those models that did not include childhood symptoms (Models 1 and 2). We also found a positive association with the use of barrier cream and other skin care products (not further specified), but after controlling for other factors (Models 2 and 3, Table 6) the association with barrier cream was no longer significant. There was no association between current hand/arm dermatitis and the number of years employed as a cleaner. Childhood dermatitis was strongly associated with current dermatitis (Table 6, Models 1 and 3) whereas TEWL and atopy were not.

For hand/arm urticaria the main risk factors were frequent hand exposure to water and cleaning products, and use of decalcifiers/acids and other (non-specified) cleaning products (Table 6, Model 1), however, after controlling for other occupational factors (Model 2) and childhood urticaria (Model 3) these associations were no longer statistically significant. The number of years worked as a cleaner was a risk factor even after controlling for age, but this was statistically significant only for those who worked as a cleaner 3–10 years (Table 6) and not for those working >10 years as a cleaner. Regular hand washing significantly reduced (2–5 times) the risk of hand/arm urticaria, and hand drying after washing reduced it by approximately 5 times (OR 0.2; 95%CI 0.1, 0.8; Table 6). Childhood urticaria was strongly associated with current urticaria (Table 6, Models 1 and 3); this was not the case for TEWL and atopy.

TEWL measured at the back of the hand was inversely associated with the use of barrier cream (mean difference: –1.84 g/m²/h; 95%CI –3.64, –0.03) after controlling for all other co-variables, but no other significant associations with TEWL were found (data not shown).

Discussion

We found an increased risk of both hand/arm dermatitis and urticaria in cleaners. Skin barrier function (measured as TEWL) was also adversely affected. The prevalence of atopy did not differ between cleaners and reference workers, and atopy only moderately affected associations with skin symptoms. Significant associations with risk and protective factors were identified, but these differed markedly for dermatitis and urticaria.

This study had several limitations. It was a cross-sectional study, which was not able to take into account

Table 6. Associations between exposures, cleaning activities and host factors, and current hand/arm dermatitis and urticaria in cleaners ($n = 425$).

Exposure/cleaning activity	Hand/arm dermatitis in past 3 months ($n = 63$)						Hand/arm urticaria in past 3 months ($n = 47$)					
	N^a	Model 1 OR (95% CI) ^a	Model 2 OR (95% CI) ^b	Model 3 OR (95% CI) ^c	N^d	Model 1 OR (95% CI) ^a	Model 2 OR (95% CI) ^b	Model 3 OR (95% CI) ^c	N^d	Model 1 OR (95% CI) ^a	Model 2 OR (95% CI) ^b	Model 3 OR (95% CI) ^c
Years worked as a cleaner												
<3 years ($n = 134$)	23	Ref	Ref	Ref	12	Ref	Ref	Ref		Ref		Ref
3–10 years ($n = 141$)	17	0.9 (0.4–1.8)	0.7 (0.3–1.6)	0.7 (0.3–1.7)	21	2.4 (1.0–5.3)*	3.0 (1.1–8.1)*	3.0 (1.1–8.1)*		3.2 (1.1–9.0)*		3.2 (1.1–9.0)*
>10 years ($n = 150$)	23	1.4 (0.6–3.0)	1.2 (0.5–2.9)	0.9 (0.3–2.3)	14	1.5 (0.6–3.9)	1.6 (0.5–5.3)	1.6 (0.5–5.3)		1.5 (0.5–5.3)		1.5 (0.5–5.3)
Type of cleaning												
Homes/schools/offices/shops/hotels ($n = 175$)	29	Ref	Ref	Ref	26	Ref	Ref	Ref		Ref		Ref
Hospital ($n = 126$)	14	0.8 (0.4–1.5)	0.4 (0.2–1.1)	0.3 (0.1–0.8)	14	0.8 (0.4–1.6)	1.1 (0.4–2.8)	1.1 (0.4–2.8)		1.0 (0.4–2.7)		1.0 (0.4–2.7)
Café/restaurant/kitchen ($n = 32$)	6	1.3 (0.5–3.4)	0.8 (0.2–2.6)	0.8 (0.2–2.8)	4	0.8 (0.3–2.4)	0.8 (0.2–3.0)	0.8 (0.2–3.0)		0.6 (0.2–2.4)		0.6 (0.2–2.4)
Industrial ($n = 67$)	10	0.9 (0.4–2.0)	1.2 (0.2–6.2)	1.5 (0.3–7.8)	2	0.2 (0.0–0.9)**	0.4 (0.0–4.6)	0.4 (0.0–4.6)		0.2 (0.0–3.4)		0.2 (0.0–3.4)
Outside ($n = 21$)	4	1.1 (0.3–3.6)	0.7 (0.2–2.8)	0.7 (0.2–3.1)	1	0.3 (0.0–2.4)	0.4 (0.0–3.7)	0.4 (0.0–3.7)		0.4 (0.0–3.4)		0.4 (0.0–3.4)
Cleaning activity (≥ 1 day/wk vs. <1 day/wk)												
Dusting/sweeping/vacuuming ($n = 366$)	54/9	1.1 (0.5–2.4)	0.6 (0.2–2.2)	0.7 (0.2–2.7)	45/2	3.4 (0.8–15.1)	2.3 (0.3–15.9)	2.3 (0.3–15.9)		2.0 (0.3–16.1)		2.0 (0.3–16.1)
Mopping/wet cleaning/damp wiping ($n = 395$)	60/3	1.7 (0.5–5.7)	2.0 (0.4–9.4)	1.7 (0.3–9.4)	45/2	1.6 (0.4–6.9)	1.6 (0.2–12.0)	1.6 (0.2–12.0)		2.0 (0.3–16.2)		2.0 (0.3–16.2)
Cleaning toilets ($n = 323$)	50/13	1.4 (0.7–2.9)	1.1 (0.4–3.2)	1.2 (0.4–3.6)	40/7	1.6 (0.7–4.0)	1.1 (0.3–4.0)	1.1 (0.3–4.0)		0.9 (0.3–3.5)		0.9 (0.3–3.5)
Polishing, waxing, shampooing ($n = 95$)	18/45	1.8 (1.0–3.4)#	1.6 (0.7–3.3)	1.6 (0.7–3.4)	13/34	1.5 (0.6–3.4)	1.0 (0.4–2.3)	1.0 (0.4–2.3)		1.2 (0.5–3.1)		1.2 (0.5–3.1)
Cleaning windows/mirrors ($n = 320$)	50/13	1.4 (0.7–2.7)	1.2 (0.5–3.1)	1.0 (0.4–2.8)	38/9	1.2 (0.6–2.7)	0.6 (0.2–1.5)	0.6 (0.2–1.5)		0.4 (0.2–1.2)		0.4 (0.2–1.2)
Cleaning the kitchen ($n = 243$)	38/25	1.3 (0.8–2.4)	1.5 (0.7–3.1)	1.5 (0.7–3.2)	25/22	0.8 (0.4–1.5)	0.5 (0.2–1.2)	0.5 (0.2–1.2)		0.6 (0.3–1.3)		0.6 (0.3–1.3)
Washing/soaking clothes/linen by hand ($n = 27$)	2/61	0.4 (0.1–1.7)	0.4 (0.1–1.9)	0.4 (0.1–2.0)	4/43	1.4 (0.5–4.3)	0.9 (0.2–3.9)	0.9 (0.2–3.9)		1.0 (0.2–4.5)		1.0 (0.2–4.5)
Washing clothes by machine ($n = 58$)	7/56	0.8 (0.3–1.8)	0.9 (0.3–2.5)	0.5 (0.2–1.7)	9/38	1.4 (0.6–3.1)	1.1 (0.4–3.1)	1.1 (0.4–3.1)		0.9 (0.3–2.7)		0.9 (0.3–2.7)
Cleaning industrial machinery ($n = 57$)	8/55	0.8 (0.3–2.0)	0.8 (0.1–4.5)	0.6 (0.1–3.7)	1/46	0.1 (0.0–1.0)#	0.1 (0.0–4.0)	0.1 (0.0–4.0)		0.1 (0.0–3.8)		0.1 (0.0–3.8)
Using gloves at work (yes/no) ($n = 404$)	62/1	3.2 (0.4–25.1)	3.9 (0.3–45.0)	4.2 (0.4–48.0)	43/4	0.5 (0.2–1.7)	0.6 (0.1–3.3)	0.6 (0.1–3.3)		0.6 (0.1–3.8)		0.6 (0.1–3.8)
Hand washing at work												
0–5 times/day ($n = 122$)	17	Ref	Ref	Ref	18	Ref	Ref	Ref		Ref		Ref
6–10 times/day ($n = 137$)	23	1.5 (0.7–2.9)	1.7 (0.7–3.9)	1.8 (0.7–4.3)	10	0.4 (0.2–1.0)*	0.3 (0.1–0.7)**	0.3 (0.1–0.6)**		0.2 (0.1–0.6)**		0.2 (0.1–0.6)**
11–20 times/day ($n = 92$)	15	1.4 (0.7–3.2)	1.6 (0.6–4.1)	1.4 (0.5–3.8)	8	0.5 (0.2–1.1)#	0.3 (0.1–0.9)**	0.3 (0.1–0.9)**		0.3 (0.1–0.9)*		0.3 (0.1–0.9)*
>20 times ($n = 74$)	8	0.9 (0.4–2.3)	0.7 (0.2–2.1)	0.9 (0.3–2.8)	11	0.9 (0.4–2.2)	0.6 (0.2–1.6)	0.6 (0.2–1.7)		0.6 (0.2–1.7)		0.6 (0.2–1.7)
Hand drying after washing (often/sometimes) ($n = 22$)	59/4	0.9 (0.3–2.8)	0.7 (0.2–2.4)	0.8 (0.2–3.5)	41/6	0.3 (0.1–0.8)**	0.2 (0.1–0.8)**	0.2 (0.1–0.8)**		0.2 (0.0–0.8)*		0.2 (0.0–0.8)*
Hands exposed to water without gloves												
Never ($n = 162$)	14	Ref	Ref	Ref	15	Ref	Ref	Ref		Ref		Ref
<1/2 h/day ($n = 149$)	27	2.3 (1.1–4.6)*	2.6 (1.2–6.0)*	2.7 (1.2–6.4)*	19	1.3 (0.6–2.7)	1.1 (0.4–2.8)	1.1 (0.4–2.8)		1.0 (0.4–2.6)		1.0 (0.4–2.6)
1/2–2 h/day ($n = 61$)	12	2.7 (1.1–6.2)*	2.9 (1.1–8.1)*	3.3 (1.1–9.9)*	5	0.9 (0.3–2.5)	0.5 (0.1–1.9)	0.5 (0.1–1.9)		0.4 (0.1–1.7)		0.4 (0.1–1.7)
2–5 h/day ($n = 35$)	6	1.9 (0.6–5.3)	4.6 (1.2–18.3)*	7.1 (1.7–29.8)**	3	0.8 (0.2–3.1)	0.3 (0.1–1.6)	0.3 (0.1–1.9)		0.3 (0.1–1.9)		0.3 (0.1–1.9)
>5 h/day ($n = 18$)	4	2.6 (0.7–9.2)	6.6 (1.2–37.2)*	9.1 (1.5–56.2)*	5	3.4 (1.0–11.1)*	0.9 (0.2–5.4)	0.9 (0.2–5.4)		0.8 (0.1–5.4)		0.8 (0.1–5.4)
Hands exposed to cleaning products w/o gloves												
Never ($n = 220$)	27	Ref	Ref	Ref	16	Ref	Ref	Ref		Ref		Ref
<1/2 h/day ($n = 103$)	22	1.9 (1.0–3.6)*	1.2 (0.6–2.7)	1.2 (0.5–2.6)	14	1.9 (0.9–4.1)	1.2 (0.5–3.3)	1.2 (0.5–3.3)		1.1 (0.4–3.0)		1.1 (0.4–3.0)
1/2–2 h/day ($n = 56$)	10	1.6 (0.7–3.6)	0.9 (0.3–2.5)	0.6 (0.2–1.8)	6	1.5 (0.6–4.1)	1.7 (0.5–6.1)	1.7 (0.5–6.1)		1.7 (0.4–7.1)		1.7 (0.4–7.1)
2–5 h/day ($n = 32$)	2	0.5 (0.1–2.1)	0.2 (0.0–1.1)	0.1 (0.0–0.7)*	6	2.7 (0.9–7.5)	3.5 (0.8–15.2)	3.5 (0.8–15.2)		3.4 (0.7–16.7)		3.4 (0.7–16.7)
>5 h/day ($n = 14$)	2	1.1 (0.2–5.3)	0.3 (0.0–2.1)	0.3 (0.0–2.0)	5	6.5 (1.9–22.0)**	3.6 (0.6–20.5)	3.6 (0.6–20.5)		4.2 (0.7–26.4)		4.2 (0.7–26.4)
Use of skin care products												
Never ($n = 128$)	27	Ref	Ref	Ref	23	Ref	Ref	Ref		Ref		Ref
Moisturiser ($n = 234$)	11	0.9 (0.4–1.7)	1.0 (0.5–2.3)	0.9 (0.4–2.0)	7	0.8 (0.4–1.7)	0.7 (0.3–1.7)	0.7 (0.3–1.7)		0.7 (0.3–1.7)		0.7 (0.3–1.7)
Barrier cream ($n = 40$)	8	(1.1–6.6)*	2.1 (0.7–5.8)	2.1 (0.7–6.4)	4	1.8 (0.7–4.9)	2.5 (0.7–8.3)	2.5 (0.7–8.3)		2.1 (0.6–7.6)		2.1 (0.6–7.6)
Other ($n = 23$)	17	3.5 (1.2–9.9)**	5.3 (1.6–18.1)**	5.1 (1.4–18.5)*	13	1.6 (0.5–5.5)	1.4 (0.4–5.8)	1.4 (0.4–5.8)		1.7 (0.4–7.3)		1.7 (0.4–7.3)

(Continued)

Table 6. (Continued).

Exposure/cleaning activity	Hand/arm dermatitis in past 3 months (<i>n</i> = 63)				Hand/arm urticaria in past 3 months (<i>n</i> = 47)			
	<i>N</i> [†]	Model 1 OR (95% CI) ^a	Model 2 OR (95% CI) ^b	Model 3 OR (95% CI) ^c	<i>N</i> [†]	Model 1 OR (95% CI) ^a	Model 2 OR (95% CI) ^b	Model 3 OR (95% CI) ^d
Use of cleaning products (often vs. sometimes/never)								
Washing powder (<i>n</i> = 386)	56	0.8 (0.3–2.0)	0.8 (0.3–2.3)	0.7 (0.2–2.0)	43	0.9 (0.3–2.7)	0.6 (0.2–2.3)	0.6 (0.2–2.4)
Polishes/waxes (<i>n</i> = 81)	13	1.2 (0.6–2.3)	1.3 (0.5–3.0)	1.6 (0.6–4.0)	7	0.7 (0.3–1.5)	0.8 (0.3–2.1)	0.7 (0.3–2.1)
Liquid multiuse cleaner (<i>n</i> = 280)	34	0.6 (0.3–1.0)*	0.5 (0.3–1.1)#	0.6 (0.3–1.2)	28	0.6 (0.3–1.2)	0.8 (0.4–1.8)	0.7 (0.3–1.8)
Bleach (<i>n</i> = 195)	31	1.3 (0.8–2.3)	1.4 (0.7–2.9)	1.3 (0.6–2.8)	26	1.5 (0.8–2.8)	1.9 (0.9–4.1)	2.1 (0.9–4.8)
Ammonia (<i>n</i> = 101)	15	1.1 (0.6–2.0)	1.0 (0.5–2.3)	1.0 (0.4–2.2)	12	1.1 (0.6–2.3)	1.0 (0.4–2.6)	1.2 (0.5–3.2)
Decalcifiers/acids (<i>n</i> = 34)	5	1.1 (0.4–2.9)	0.8 (0.2–2.8)	0.6 (0.1–2.2)	8	2.8 (1.2–6.8)*	2.8 (0.9–8.7)	2.6 (0.8–8.3)
Solvents/stain removers (<i>n</i> = 44)	11	1.9 (0.9–4.1)#	2.5 (0.9–6.5)#	3.1 (1.1–8.7)*	7	1.5 (0.6–3.6)	1.0 (0.3–3.1)	1.1 (0.3–3.6)
Other cleaning products not specified (<i>n</i> = 41)	8	1.4 (0.6–3.2)	1.3 (0.5–3.8)	1.1 (0.3–3.3)	8	2.1 (0.9–5.0)#	1.6 (0.6–4.6)	1.4 (0.4–4.2)
Host factors								
Atopy (<i>n</i> = 212)	33	1.2 (0.7–2.0)	–	–	27	1.2 (0.6–2.3)	–	–
TEWL (<i>n</i> = 289) [‡]	45	–	–	–	30	–	–	–
Back of hand	–	1.0 (1.0–1.1)	–	–	–	–	–	–
Volar forearm	–	1.0 (0.9–1.1)	–	–	–	–	–	–
Childhood (≤18 years) dermatitis (<i>n</i> = 28)	28	7.6 (3.3–17.4)**	–	14.8 (4.8–45.9)**	–	–	–	–
Childhood (≤18 years) urticaria (<i>n</i> = 36)	–	–	–	–	36	5.5 (2.5–11.9)**	–	9.6 (3.3–27.7)**

Note: Ref = reference.

^aAdjusted for age, sex, ethnicity, smoking.^bAdjusted for age, sex, ethnicity, smoking and all other exposure variables in the table.^cAdjusted for age, sex, ethnicity, smoking, all other exposure variables in the table and childhood eczema.^dAdjusted for age, sex, ethnicity, smoking, all other exposure variables in the table and childhood urticaria.[†]*p* < 0.10^{*}*p* < 0.05; ^{**}*p* < 0.01; [‡]Number of workers with current eczema/urticaria.[#]For brevity only TEWL results for back of hand and volar forearm are shown.

temporal associations between work-related risk factors and symptoms. We focused on dermatitis and urticaria in the last 3 months, thereby increasing the likelihood that symptoms were work-related, but we cannot exclude that symptoms developed prior to commencing work as a cleaner. In fact, of all cleaners with current dermatitis ($n = 63$), 44% had dermatitis prior to the age of 18 years (of those with urticaria ($n = 47$), 77% had childhood urticaria). However, controlling analyses for childhood dermatitis or urticaria (both of which were strongly associated with current symptoms; Table 6) generally strengthened the associations with work-related risk factors suggesting that these associations were unlikely due to bias related to childhood symptoms. Analyses excluding cleaners with childhood dermatitis or urticaria resulted in unstable estimates (due to lower number of cases) with very wide confidence intervals and could therefore not be used to further clarify the work-relatedness of the reported symptoms.

The low response rate in reference workers (34%) compared to that in cleaners (74%) is of concern and could have produced selection bias. However, subjects with symptoms are generally more likely to participate than those without, thus leading to inflated symptom prevalences in the comparison group that would, if anything, produce reduced odds ratios when comparing the cleaners to the reference group. However, this could not be verified as we were not able to collect the reasons for non-participation; also, no symptom information from non-responders was available. Our study may have also been subject to “survivor bias” or the “healthy worker effect,” if workers most affected by dermatitis/urticaria were more likely to have left the workforce, although once again, this would result in an underestimation of the risk [26]. Any resulting bias would be expected to be small in comparisons between the cleaners and the reference group, since both were currently working, but bias could be greater when analysing prevalence by years of employment as a cleaner. In fact, some evidence of a healthy worker survivor bias was found for urticaria. This was associated with the number of years worked as a cleaner, but only up to ten years after which the effect reduced and was no longer statistically significant (Table 6).

There were significant differences in sex, age, ethnicity, and smoking habits between cleaners and reference workers, but these were controlled for in the analyses. We used two populations for our reference group (retail workers and bus drivers); however, sensitivity analyses excluding bus drivers did not significantly change the risk estimates (data not shown). Moreover, the study results were consistent with previous international studies, which also showed increased risks of occupational dermatitis in cleaners [14–19] and identified similar risk factors (e.g. wet work) [1,12,13].

There were other limitations. Current dermatitis and urticaria were defined based on self-reported symptoms

that were not confirmed by a clinical assessment, and therefore some misclassification may have occurred. However, the NOSQ-2002 questionnaire is extensively used in other population studies and is well validated for dermatitis, although, to our knowledge, not for urticaria [21]. Also, the definition used to assess dermatitis and urticaria was the same for cleaners and reference workers and comparisons are therefore considered to be valid. To reduce recall bias we defined current dermatitis and urticaria on the basis of symptoms which had occurred in the preceding three months. Using a seven day or 12-month cut-off did not markedly change the results (data not shown). Nonetheless, some of the results need to be interpreted with caution. In particular, the associations based on self-reported skin symptoms due to glove-use (Table 2) are prone to bias as participants may be aware of the potential for extensive glove-use to cause skin symptoms (in contrast to potentially lesser-known risk factors). Also, although a relatively large study (425 cleaners and 281 reference workers), the number of symptomatic workers with specific exposures were sometimes low resulting in wide confidence limits (Table 6) reducing the precision of effect estimates.

This study has shown that cleaners continue to have an increased risk of work-related hand dermatitis. This finding is consistent with another contemporary study from Spain [19]. As previously shown [12,13], wet work remains one of the most important risk factors for hand dermatitis in cleaners. In fact, our study showed that even relatively low exposures ($<1/2$ h/day) increased the risk while exposure in excess of 5 h/day was associated with a more than sixfold risk, although this high risk was found in a very small subgroup as demonstrated by wide confidence limits. However, in contrast with the Spanish study [19], which found significant associations with several cleaning products including hydrochloric acid, dust mop products, ammonia, bleach, multi-use cleaning products and perfumed cleaning products, we found no significant associations with specific cleaning products apart from solvents/stain removers (Table 6). We also found a positive association with skin care products, but this is most likely due to reverse causation, although excluding those who indicated using barrier cream did not significantly alter the results (data not shown).

This study showed that cleaners also have an increased risk of hand/arm urticaria (as defined by itchy wheals in the past three months) and are more than three-times as likely as the reference population to seek medical treatment for it (Table 3). Although occupational urticaria is well described in other settings (e.g. food handlers), it has not previously been reported in cleaners. Years worked as a cleaner was significantly associated with urticaria, but the effect reduced after 10 years; as discussed above, this may be due to a healthy worker survivor effect. Urticaria was also strongly associated with hand exposure to cleaning products (Table 6) and

use of decalcifiers/acids, but after controlling for other factors these associations were no longer statistically significant. Interestingly, hand washing and hand drying after washing significantly reduced the risk of urticaria by up to fivefold.

There are several other novel aspects to this study including the use of TEWL measurements to assess the effects of cleaning on skin barrier function. Mean TEWL values were within normal range according to the manufacturers guidelines (i.e. $<20 \text{ g/m}^2/\text{h}$). Also, TEWL values were highly correlated, with the strongest correlations for back of hand, volar forearm and upper arm (r 0.65–0.73; $p < 0.0001$; data not shown) and somewhat lower correlations for upper arm TEWL (r 0.38–0.45, $p < 0.001$; data not shown), suggesting TEWL may be a constitutive trait. Nonetheless, cleaners had consistently higher TEWL than reference workers, which was only found for measurements conducted on the hand and forearm and not the upper arm, which is not typically exposed to “wet work” and cleaning products. This suggests that localised reduced skin barrier function in cleaners is due to work-related factors and/or possibly the effects of lichenification associated with chronic eczema, although no direct association was found with skin symptoms in cleaners (see below). To our knowledge this is the first study to report this finding in cleaners. Reassuringly, TEWL was inversely and strongly associated with the use of barrier cream; however, in cleaners it was not associated with dermatitis and/or urticaria symptoms, nor was it associated with any of the investigated exposures (data not shown). Interestingly, in the reference population a positive association between TEWL and dermatitis was found. The reason why no association was found in cleaners is unclear, but it may be that TEWL in cleaners is characterised by greater temporal variance (due to more variable exposures) as also suggested by somewhat higher standard deviations for TEWL measurements on the back of the hand, and top and volar forearm (i.e. those areas most likely to be exposed to wet work and cleaning agents) in cleaners compared to the reference population. If so, measurements taken at one point in time, as in our study, may not accurately reflect skin barrier function for the preceding three months – the time period used to define current symptoms. Alternatively, cleaners may have underreported mild dermatitis (which may contribute to localised increased TEWL), thus resulting in measurement error and a subsequent lack of association.

Although atopy has been suggested to increase the risk of occupational dermatitis and urticaria [1,27], only a few studies have objectively assessed atopy. Instead most studies have used self-reported histories of allergies [19]. In our study the prevalence of atopy (based on skin prick tests) did not significantly differ between cleaners and reference workers. Also, no significant association between atopy and current hand dermatitis or urticaria was found (Table 6). This strongly suggests that atopic

mechanisms do not directly contribute to skin symptoms in cleaners. Instead, and consistent with the identified risk factors, it is likely to involve non-atopic or irritant mechanisms. However, as associations with symptoms were somewhat more pronounced in atopics it may be that they are more susceptible for irritant exposures and associated non-atopic symptoms.

In conclusion, this study has shown that cleaners continue to have an increased risk of work-related (non-atopic) hand dermatitis. It also showed an increased risk of urticaria and localised loss of skin barrier function. The study identified several modifiable risk (wet work) and protective (hand washing and drying) factors for eczema and urticaria, respectively, which represent feasible targets for prevention.

Acknowledgements

We thank the study participants and the Service and Food Workers Union (SFWU) for their generous support, and Elizabeth Harding, Angela Thurston, Leigh Emmerton, Heather Duckett, Kerry Cheung, Michelle Gray, Tracey Whaanga and Emma Nuttall for conducting the interviews, TEWL measurements and skin prick tests. We also thank Professor Pieter-Jan Coenraads for his advice and support at the initial stages of the study.

Disclosure statement

None of the authors have a conflict of interest regarding the research reported in this paper.

Funding

The Centre for Public Health Research is funded by a Programme Grant from the Health Research Council (HRC) of New Zealand, and this research was funded by this Programme Grant and a joint HRC/Department of Labour (now WorkSafe New Zealand) Partnership Grant.

ORCID

Tania Slater <http://orcid.org/0000-0001-8390-2015>

Mathangi Shanthakumar <http://orcid.org/0000-0003-2392-0603>

Lissa Judd <http://orcid.org/0000-0001-9043-8230>

References

- [1] Diepgen TL, Coenraads PJ. The epidemiology of occupational contact dermatitis. *Int Arch Occup Environ Health*. 1999;72:496–506.
- [2] Bauer A, Schmitt J, Bennett C, et al. Interventions for preventing occupational irritant hand dermatitis. *Cochrane Database Syst Rev*. 2010;16:CD004414.
- [3] Lerbaek A, Kyvik KO, Ravn H, et al. Clinical characteristics and consequences of hand eczema – an 8-year follow-up study of a population-based twin cohort. *Contact Dermatitis*. 2008;58:210–216.
- [4] Meding B, Lantto R, Lindahl G, et al. Occupational skin disease in Sweden – a 12-year follow-up. *Contact Dermatitis*. 2005;53:308–313.

- [5] Meding B, Wrangsjö K, Jarvholm B. Fifteen-year follow-up of hand eczema: persistence and consequences. *Br J Dermatol*. 2005;152:975–980.
- [6] Hogan DJ, Dannaker CJ, Maibach HI. The prognosis of contact dermatitis. *J Am Acad Dermatol*. 1990;23:300–307.
- [7] Cahill J, Keegel T, Nixon R. The prognosis of occupational contact dermatitis in 2004. *Contact Dermatitis*. 2004;51:219–226.
- [8] Politiek K, Oosterhaven JAF, Vermeulen KM, et al. Systematic review of cost-of-illness studies in hand eczema. *Contact Dermatitis*. 2016;75:67–76.
- [9] Zock JP. World at work. *Occup Environ Med*. 2005;62:581–584.
- [10] Cherry N, Meyer JD, Adisesh A, et al. Surveillance of occupational skin disease: EPIDERM and OPRA. *Br J Dermatol*. 2002;142:1128–1134.
- [11] Carøe TK, Ebbelhøj N, Agner T. A survey of exposures related to recognized occupational contact dermatitis in Denmark in 2010. *Contact Dermatitis*. 2014;70:56–62.
- [12] Jungbauer FH, Van Der Harst JJ, Schuttelaar ML, et al. Characteristics of wet work in the cleaning industry. *Contact Dermatitis*. 2004;51:131–134.
- [13] Flyvholm MA, Lindberg M. OEESC-2005—summing up on the theme irritants and wet work. *Contact Dermatitis*. 2006;55:317–321.
- [14] Singgih SI, Lantinga H, Nater JP, et al. Occupational hand dermatoses in hospital cleaning personnel. *Contact Dermatitis*. 1986;14:14–19.
- [15] Gawkrödger DJ, Lloyd MH, Hunter JA. Occupational skin disease in hospital cleaning and kitchen workers. *Contact Dermatitis*. 1986;15:132–135.
- [16] Nielsen J. The occurrence and course of skin symptoms on the hands among female cleaners. *Contact Dermatitis*. 1996;34:284–291.
- [17] Diepgen TL. Occupational skin-disease data in Europe. *Int Arch Occup Environ Health*. 2003;76:331–338.
- [18] Lynde CB, Obadia M, Ribeiro M, et al. Cutaneous and respiratory symptoms among professional cleaners. *Occup Med*. 2009;59:249–254.
- [19] Mirabelli MC, Vizcaya D, Margarit AM, et al. Occupational risk factors for hand dermatitis among professional cleaners in Spain. *Contact Dermatitis*. 2012;66:188–196.
- [20] Lewis RD, Ong KH, Emo B, et al. Do new wipe materials outperform traditional lead dust cleaning methods? *J Occup Environ Hyg*. 2012;9:524–533.
- [21] Susitaival P, Flyvholm MA, Meding B, et al. Nordic Occupational Skin Questionnaire (NOSQ-2002): a new tool for surveying occupational skin diseases and exposure. *Contact Dermatitis*. 2003;49:70–76.
- [22] Pinnagoda J, Tupker RA, Agner T, et al. Guidelines for transepidermal water loss (TEWL) measurement. A report from the Standardization Group of the European Society of Contact Dermatitis. *Contact Dermatitis*. 1990;22:164–178.
- [23] Douwes J, McLean D, Slater T, et al. Pine dust, atopy and lung function: a cross-sectional study in sawmill workers. *Eur Respir J*. 2006;28:791–798.
- [24] Pearce N. Effect measures in prevalence studies. *Environ Health Perspect*. 2004;112:1047–1050.
- [25] Greenland S, Pearce N. Statistical foundations for model-based adjustments. *Annu Rev Public Health*. 2015;36:89–108.
- [26] Le Moual N, Kauffmann F, Eisen EA, et al. The healthy worker effect in asthma: work may cause asthma, but asthma may also influence work. *Am J Respir Crit Care Med*. 2008;177:4–10.
- [27] Chew AL, Maibach HI. Occupational issues of irritant contact dermatitis. *Int Arch Occup Environ Health*. 2003;76:339–346.