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

**Running head: Dermatitis and urticaria in cleaners**

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Conflicts of interest

The authors have no conflicts of interest.

Author contributions

JD was the Principal Investigator and was involved in all aspects of the study; TS was the study coordinator and was involved in all aspects of the study; MS has conducted the statistical analyses and has significantly contributed to the writing of the manuscript; DMcL, RTF, LJ and NP contributed to the design of the study, the epidemiological analyses and the writing of the manuscript.

**Abstract**

**Background:** Cleaners have an increased risk of hand dermatitis.

**Objectives:** To assess the risk and determinants of dermatitis, urticaria and loss of skin barrier function in cleaners, and any modifying effects of atopy.

**Methods:** Dermatitis, urticaria, atopy and skin barrier function were assessed in 425 cleaners and 281 reference workers using questionnaires, skin prick tests, and transepidermal water loss (TEWL) measurements.

**Results:** Cleaners had an increased risk of dermatitis (14.8% versus 10.0%; OR=1.92, $p<0.05$) and urticaria (11% versus 5.3%; OR=2.37, $p<0.05$) and were more likely to develop dermatitis as adults (17.6% versus 11.4%; OR=1.77, $p<0.05$). TEWL on the hand and forearm was significantly elevated (15.5% and 17.9% respectively) in cleaners. Atopy did not affect risk and was not associated with symptoms. Wet-work was a strong risk factor for dermatitis, showing a dose-response association with ORs ranging from 2.6-6.5 ($p<0.05$). Hand washing and drying reduced the risk of urticaria two to five-fold ($p<0.05$). Skin care products were associated with dermatitis (likely due to reverse causation).

**Conclusions:** Cleaners have an increased risk of work-related hand/arm dermatitis, urticaria and loss of skin barrier function independent of atopy. Wet work increased the risk of dermatitis and hand washing/drying reduced the risk of urticaria.

Word count: 199

Keywords: dermatitis, urticaria, occupational, transepidermal water loss, cleaners, atopy, risk factors, wet work

## Introduction

Occupational dermatitis is one of the most common work-related illnesses, and has been estimated to account for up to 40-70% of the total burden of occupational disease (1-3). Morbidity is substantial with a reported average loss of 11 work days annually in 20-25% of affected workers (4) equating to a potential 25% of all lost work days (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 (6-9). Atopy has been shown to be the strongest risk factor for poor prognosis of chronic dermatitis (6).

Workers in the cleaning industry, which is a large fraction of the workforce globally (10), 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 (1,11). 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 (1,12,13). In Denmark cleaners have the highest incidence of notified occupational skin diseases with 13.2 cases per 1,000 per year (14), and epidemiological studies in other countries have also shown an elevated risk of dermatitis in cleaners (15-19). 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, risk and determinants of occupational dermatitis and urticaria in cleaners; 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.

## Materials and methods

### Study population

Work-related 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, 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 to 3 months, 3-12 months, or more than 12 months ago). 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 to 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 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, medication, 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, UK). Results are expressed in $g/m^2/h$. Measurements were taken on the back of the hand and the top and volar surface on the forearm according to published guidelines (22). We also took measurements on the upper arm (which was not exposed) 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.

**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 aeroallergen solutions were tested: positive control (histamine), negative control (diluent), cat, dog, grass mix, *Alternaria*, *Cladosporium*, *Penicillium*, and house dust mite (Hollister-Stier Laboratories, Spokane, WA, USA). All tests were read at 15 minutes. A positive reaction was defined as a wheal with a mean diameter ≥3mm, 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. Initially, all analyses were conducted for one exposure variable at a time, adjusted for smoking, age, sex and ethnicity (Model 1). We subsequently conducted multiple logistic and linear 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. Finally, we 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, only the results for model 1 and 2 are shown.

**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 low and was considerably less than those reported by the cleaners (data not shown).

Cleaners were more likely to report current hand/arm dermatitis (OR=1.92, $p<0.05$) and develop dermatitis in adult life (OR= 1.77, $P<0.05$; Table 2). They also more frequently visited a doctor as an adult for hand, wrist or forearm dermatitis (OR=1.50), but this did not reach statistical significance (Table 2). Cleaners also had an increased risk of current hand/arm urticaria (OR=2.37, $p<0.05$) and were three times as likely to have urticaria after the age of 18 (not statistically significant) and to see a doctor as an adult for urticaria (OR=3.59, $p<0.05$; Table 2). 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, compared to 6.8% and 1.8% in the reference group respectively (OR=3.9 and 6.8, $p<0.01$; Table 2).

TEWL on the hand and forearm was significantly elevated (15.5 and 17.9% respectively) in cleaners compared to the reference group (Table 3) 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 (data not shown). In contrast, TEWL in reference workers was significantly associated with current eczema with the strongest association for TEWL measured at the hand (mean difference: 1.66 $g/m^2/h$, $p<0.01$). Urticaria was *inversely* associated with TEWL for both hand and volar forearm, but only in the reference group (data not shown).

Cleaners had a reduced risk of atopy, which was statistically significant only for cat allergens (OR=0.54, $p<0.05$) and no association was found between atopy and skin symptoms and TEWL (data not shown). Analyses comparing cleaners and reference workers stratified by atopy showed that the risk estimates for dermatitis and urticaria did not differ between atopics and non-atopics (data not shown).

Hand exposure to water (without wearing gloves) was strongly associated in a dose-dependent fashion ($p<0.05$) 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 hours/day and >5 hours had a 5 and 7 fold risk respectively ($p<0.05$; Table 4); exposures of <½ an hour and <2 hours were associated with a 3-fold increased risk ($p<0.05$). The use of solvents and stain removers was positively associated with dermatitis, but this was only borderline statistically significant ($p=0.07$). 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 (model 2, Table 4) the association with barrier cream was no longer significant. There was no association between current eczema and the number of years employed as a cleaner.

For 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 4, model 1), however, after controlling for other occupational factors (model 2) 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 4) and not for those working >10 years as a cleaner. Regular hand washing significantly reduced (2-4 fold) the risk of urticaria, and hand drying after washing reduced it 5-fold (Table 4).

TEWL measured at the back of the hand was inversely associated with the use of barrier cream (mean difference: -1.05 g/m2/h, $p<0.05$) 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 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 was not associated with skin symptoms. Significant risk and protective factors were identified, but these differed markedly for eczema and urticaria.

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. 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 urticarial. 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 4). There were also 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) suggesting results are robust. Moreover, the study results were consistent with previous international studies which also showed increased risks of occupational dermatitis in cleaners (15-19) and identified similar risk factors (e.g. wet work) (1,12,13). Thus, the odds ratio estimates are robust and consistent with previous studies, but may have been underestimated due to low response rates in the reference population and the potential of healthy worker survivor bias.

Current dermatitis and urticaria were defined based on self-reported symptoms which 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 (21). Also, the definition used to assess dermatitis and urticaria was the same for cleaners and reference workers and comparisons are therefore 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); findings therefore do not appear to be affected by our chosen cut-off of three months.

This study has shown that cleaners continue to have an increased risk of work-related hand dermatitis, despite significant changes in cleaning methods (20). This finding is consistent with another recent study from Spain (19). As previously shown (1,12,13), wet work remains one the most important risk factors for hand dermatitis in cleaners. In fact, our study showed that even relatively low exposures (<1/2 hour/day) increased the risk while exposures in excess of five hours/day was associated with a more than six-fold risk. 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 which was only borderline statistically significant. We also found a positive association with skin care products, but this is most likely due to reverse causation.

This study also showed that cleaners have an increased risk of urticaria and are more than three-times as likely as the reference population to seek medical treatment for it. 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 4) 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 five-fold. Taken together, these results suggest that specific exposures to cleaning products may be a risk factor for urticaria which can be prevented by regular hand washing and subsequent drying.

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. Cleaners had consistently higher TEWL than reference workers, and this 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 strongly suggests that localised reduced skin barrier function in cleaners is due to work-related factors. 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. 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). 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.

Although atopy has been suggested to increase the risk of occupational dermatitis and urticarial (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 differ between cleaners and reference workers, and atopy was not associated with dermatitis and urticaria, suggesting that atopic mechanisms do not contribute to skin symptoms in cleaners. Instead, and consistent with the identified risk factors, it is likely to involve non-allergic mechanisms.

Few intervention studies in cleaners have been conducted (28). Considering the high burden of dermal symptoms, its ability to develop into a chronic condition, and the fact that the cleaning industry

involves a large proportion of the workforce, these studies are now urgently needed. Based on our study, and other international studies, feasible interventions include changes from wet to dry cleaning, more appropriate use of gloves and skin care products, and, to reduce the risk of urticaria, encouraging hand washing and drying following exposure to cleaning products.

In conclusion, despite recent changes in cleaning methods (20), which have at least partially replaced conventional wet cleaning methods, 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.

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

| | Cleaners (n=425) | | Reference (n=281) | |
|---|---|---|---|---|
| | **n** | **%** | **n** | **%** |
| Sex | | | | |
| Males | 97 | 22.8 | 142 | 50.5 |
| Females | 328 | 77.2 | 139 | 49.5 |
| Ethnicity | | | | |
| New Zealand European | 141 | 33.2 | 189 | 67.3 |
| Māori | 114 | 26.8 | 38 | 13.5 |
| Pacific | 118 | 27.8 | 29 | 10.3 |
| Other | 49 | 11.5 | 24 | 8.5 |
| Smoking status | | | | |
| Current smoker | 178 | 41.9 | 81 | 28.8 |
| Ex-smoker | 59 | 13.9 | 75 | 26.7 |
| Non-smoker | 188 | 44.2 | 124 | 44.1 |
| Type of cleaning work[1] | | | | |
| 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 |
| Years worked in current job (yrs) | 8.5 | 8.61 | 6.2 | 7.13 |
| Number of hrs/wk working as a cleaner | 33.8 | 12.08 | - | - |

[1] Cleaners 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**

| | Cleaners (n=425) | | Reference (n=281) | | |
|---|---|---|---|---|---|
| **Symptom** | **n** | **%** | **n** | **%** | **OR (95% CI)[1]** |
| **Dermatitis** | | | | | |
| Eczema ever (y/n) | 93 | 21.9 | 47 | 16.7 | 1.38 (0.90-2.11) |
| ≥1 area affected (y/n) | 102 | 24.0 | 61 | 21.7 | 1.20 (0.80-1.79) |
| Last had eczema | | | | | |
| past 7 days | 43 | 10.1 | 19 | 6.8 | 1.92 (1.14-3.23)* |
| 7 days - 3 months ago | 20 | 4.7 | 9 | 3.2 | (< 3 months vs >3 |
| 3-12 months ago | 14 | 3.3 | 10 | 3.6 | months or never) |
| >12 months ago | 26 | 6.1 | 24 | 8.5 | |
| Age when first had eczema | | | | | |
| <6 years | 11 | 2.6 | 14 | 5.0 | 1.77 (1.09-2.88)* |
| 6-14 years | 12 | 2.8 | 8 | 2.8 | (>18 yrs vs <18 or |
| 15-18 years | 5 | 1.2 | 9 | 3.2 | never) |
| >18 years | 75 | 17.6 | 32 | 11.4 | |
| Seen doctor as adult for eczema (y/n) | 59 | 13.9 | 30 | 10.7 | 1.50 (0.89-2.51) |
| Eczema improves when away from work | | | | | |
| Usually | 42 | 9.9 | 15 | 5.3 | 2.51(1.42-4.43)** |
| Sometimes | 20 | 4.7 | 6 | 2.1 | (yes vs no) |
| **Urticaria** | | | | | |
| Itchy wheals ever (y/n) | 100 | 23.5 | 47 | 16.7 | 1.31 (0.86-2.01) |
| Last had itchy wheals | | | | | |
| past 7 days | 24 | 5.6 | 6 | 2.1 | 2.37 (1.23-4.56)** |
| 7 days - 3 months ago | 23 | 5.4 | 9 | 3.2 | (<3 months vs >3 |
| 3-12 months ago | 22 | 5.2 | 12 | 4.3 | months or never) |
| >12 months ago | 31 | 7.3 | 20 | 7.1 | |
| Age when first had itchy wheals | | | | | |
| <6 years | 4 | 0.9 | 7 | 2.5 | 1.68 (0.95-2.95) |
| 6-14 years | 23 | 5.4 | 11 | 3.9 | (>18 yrs vs <18 yrs or |
| 15-18 years | 9 | 2.1 | 8 | 2.8 | never) |
| >18 years | 64 | 15.1 | 21 | 7.5 | |
| Seen doctor as adult for itchy wheals (y/n) | 38 | 8.9 | 6 | 2.1 | 3.59 (1.43-9.06)** |
| **Skin symptoms and glove use** | | | | | |
| Symptoms due to gloves (y/n) | 103 | 24.2 | 19 | 6.8 | 3.87 (2.22-6.74)** |
| Changed glove type or stopped using gloves due to symptoms (y/n) | 51 | 12.0 | 5 | 1.8 | 6.78 (2.57-17.88)** |

[1] Adjusted for age, sex, ethnicity, smoking

* p<0.05; ** p<0.01

**Table 3. Trans-epidermal water loss (TEWL) in cleaners and reference workers.**

| | Cleaners | | Reference | | | |
|---|---|---|---|---|---|---|
| | n=289 | | n=273 | | Difference[1] | |
| **Location of TEWL measurement** | Mean TEWL[2] | SD | Mean TEWL[2] | SD | Mean TEWL[2] | p-value |
| Back of hand | 7.8 | 3.74 | 6.9 | 2.86 | 1.07 | 0.0004 |
| Top forearm | 7.1 | 3.08 | 6.7 | 2.14 | 0.49 | 0.0425 |
| Volar forearm | 7.8 | 3.16 | 6.8 | 2.25 | 1.22 | <0.0001 |
| Upper arm | 7.3 | 2.82 | 7.6 | 4.84 | 0.04 | 0.9212 |

[1] Adjusted for age, sex, ethnicity, smoking
[2] Unit: grams/meter$^2$/h

**Table 4.** Associations between exposures and cleaning activities and current dermatitis and urticaria in cleaners (n=425)

| Exposure/cleaning activity | Dermatitis in past 3 months | | Urticaria in past 3 months | |
|---|---|---|---|---|
| | Model 1 OR (95% CI)[1] | Model 2 OR (95% CI)[2] | Model 1 OR (95% CI)[1] | Model 2 OR (95% CI)[2] |
| Years worked as a cleaner | | | | |
| <3 years (n=134) | Ref | Ref | Ref | Ref |
| 3-10 years (n=141) | 0.86 (0.41-1.78) | 0.68 (0.29-1.59) | 2.35 (1.03-5.34)* | 2.96 (1.08-8.13)* |
| >10 years (n=150) | 1.36 (0.62-3.00) | 1.15 (0.45-2.91 | 1.46 (0.55-3.90) | 1.62 (0.49-5.32) |
| Type of cleaning | | | | |
| Homes/schools/offices/shops/hotels (n=175) | Ref | Ref | Ref | Ref |
| Hospital (n=126) | 0.75 (0.37-1.53) | 0.43 (0.17-1.06) | 0.77 (0.37-1.58) | 1.09 (0.43-2.75) |
| Café/restaurant/kitchen (n=32) | 1.27 (0.47-3.43) | 0.79 (0.24-2.63) | 0.81 (0.26-2.53) | 0.81 (0.21-3.02) |
| Industrial (n=67) | 0.87 (0.37-2.04) | 1.21 (0.24-6.16) | 0.19 (0.04-0.85)** | 0.35 (0.03-4.60) |
| Outside (n=21) | 1.08 (0.33-3.55) | 0.70 (0.18-2.78) | 0.30 (0.04-2.38) | 0.40 (0.04-3.71) |
| Cleaning activity (≥1 day/wk vs <1 day/wk) | | | | |
| Dusting/sweeping/vacuuming (n=366) | 1.06 (0.47-2.40) | 0.59 (0.16-2.22) | 3.43 (0.78-15.07) | 2.26 (0.32-15.86) |
| Mopping/wet cleaning/damp wiping (n=395) | 1.65 (0.47-5.73) | 1.96 (0.41-9.38) | 1.57 (0.36-6.92) | 1.58 (0.21-11.95) |
| Cleaning toilets (n=323) | 1.40 (0.69-2.86) | 1.14 (0.40-3.20) | 1.62 (0.66-3.96) | 1.12 (0.31-4.01) |
| Polishing, waxing, shampooing (n=95) | 1.83 (0.98-3.42)# | 1.56 (0.74-3.32) | 1.51 (0.75-3.04) | 0.97 (0.40-2.34) |
| Cleaning windows/mirrors (n=320) | 1.36 (0.68-2.70) | 1.19 (0.46-3.12) | 1.23 (0.56-2.71) | 0.56 (0.21-1.52) |
| Cleaning the kitchen (n=243) | 1.34 (0.75-2.40) | 1.47 (0.70-3.09) | 0.77 (0.41-1.45) | 0.54 (0.24-1.18) |
| Washing/soaking clothes/linen by hand (n=27) | 0.39 (0.09-1.71) | 0.37 (0.07-1.85) | 1.40 (0.45-4.34) | 0.93 (0.22-3.89) |
| Washing clothes by machine (n=58) | 0.76 (0.31-1.83) | 0.89 (0.31-2.52) | 1.35 (0.59-3.10) | 1.07 (0.37-3.09) |
| Cleaning machinery in an industrial setting (n=57) | 0.83 (0.34-1.98) | 0.75 (0.13-4.48) | 0.13 (0.02-1.02)# | 0.13 (0.00-4.04) |
| Using protective gloves at work (yes vs no) (n=404) | 3.24 (0.42-25.13) | 3.86 (0.33-45.03) | 0.52 (0.16-1.69) | 0.60 (0.11-3.31) |
| Hand washing at work | | | | |
| 0-5 times/day (n=122) | Ref | Ref | Ref | Ref |
| 6-10 times/day (n=137) | 1.45 (0.72-2.93) | 1.69 (0.74-3.90) | 0.41 (0.18-0.95)* | 0.25 (0.09-0.68)** |
| 11-20 times/day (n=92) | 1.44 (0.65-3.19) | 1.57 (0.61-4.05) | 0.45 (0.18-1.13)# | 0.28 (0.09-0.86)** |
| >20 times (n=74) | 0.88 (0.35-2.25) | 0.71 (0.24-2.11) | 0.94 (0.40-2.21) | 0.55 (0.19-1.59) |
| Hand drying after washing (often vs sometimes) (n=22) | 0.88 (0.28-2.77) | 0.69 (0.18-2.39) | 0.29 (0.10-0.80)** | 0.19 (0.05-0.76)** |
| Hands exposed to water without gloves | | | | |
| Never (n=162) | Ref | Ref | Ref | Ref |
| < 1/2 hr/day (n=149) | 2.30 (1.14-4.62)* | 2.62 (1.15-5.97)* | 1.33 (0.64-2.74) | 1.11 (0.44-2.78) |

| | | | | |
|---|---|---|---|---|
| 1/2 - 2 hrs/day (n=61) | 2.67 (1.14-6.22)* | 2.90 (1.04-8.08)* | 0.87 (0.30-2.52) | 0.51 (0.14-1.85) |
| 2-5 hrs/day (n=35) | 1.85 (0.64-5.34) | 4.62 (1.17-18.25)* | 0.83 (0.22-3.09) | 0.28 (0.05-1.62) |
| >5 hrs/day (n=18) | 2.59 (0.73-9.19) | 6.56 (1.16-37.16)* | 3.40 (1.04-11.14)* | 0.94 (0.16-5.44) |
| Hands exposed to cleaning products w/o gloves | | | | |
| Never (n=220) | Ref | Ref | Ref | Ref |
| <1/2 hr/day (n=103) | 1.92 (1.02-3.61)* | 1.22 (0.56-2.66) | 1.91 (0.89-4.09) | 1.21 (0.45-3.27) |
| 1/2 - 2 hrs/day (n=56) | 1.61 (0.72-3.60) | 0.86 (0.29-2.54) | 1.49 (0.55-4.05) | 1.67 (0.45-6.14) |
| 2-5 hrs/day (n=32) | 0.46 (0.10-2.07) | 0.18 (0.03-1.06) | 2.66 (0.94-7.51) | 3.49 (0.80-15.18) |
| >5 hrs/day (n=14) | 1.08 (0.22-5.27) | 0.27 (0.04-2.14) | 6.46 (1.90-22.02)** | 3.60 (0.63-20.46) |
| Use of skin care products | | | | |
| Never (n=128) | Ref | Ref | Ref | Ref |
| Moisturiser (n=234) | 0.85 (0.43-1.69) | 1.01 (0.45-2.25) | 0.79 (0.38-1.68) | 0.68 (0.28-1.69) |
| Barrier cream (n=40) | 2.73 (1.13-6.64)* | 2.07 (0.73-5.85) | 1.79 (0.65-4.92) | 2.49 (0.74-8.34) |
| Other (n=23) | 3.49 1.24-9.87)** | 5.30 (1.55-18.11)** | 1.58 (0.45-5.50) | 1.42 (0.35-5.77) |
| Use of cleaning products (often vs sometimes/never) | | | | |
| Washing powder (n=386) | 0.82 (0.33-2.01) | 0.79 (0.27-2.32) | 0.89 (0.29-2.73) | 0.61 (0.16-2.26) |
| Polishes/waxes (n=81) | 1.15 (0.58-2.29) | 1.25 (0.53-2.98) | 0.65 (0.27-1.52) | 0.75 (0.27-2.08) |
| Liquid multiuse cleaner (n=280) | 0.55 (0.32-0.97)* | 0.53 (0.26-1.09)# | 0.64 (0.34-1.22) | 0.80 (0.35-1.84) |
| Bleach (n=195) | 1.31 (0.75-2.29) | 1.43 (0.71-2.87) | 1.48 (0.79-2.77) | 1.87 (0.85-4.13) |
| Ammonia (n=101) | 1.06 (0.56-2.02) | 1.02 (0.45-2.30) | 1.13 (0.56-2.29) | 1.03 (0.41-2.61) |
| Decalcifiers/acids (n=34) | 1.05 (0.38-2.86) | 0.77 (0.21-2.83) | 2.83 (1.18-6.78)* | 2.78 (0.89-8.65) |
| Solvents/stain removers (n=44) | 1.94 (0.91-4.13)# | 2.46 (0.93-6.50)# | 1.49 (0.62-3.60) | 0.99 (0.32-3.06) |
| Other cleaning products not further specified (n=41) | 1.37 (0.58-3.19) | 1.34 (0.47-3.77) | 2.11 (0.89-5.01)# | 1.64 (0.58-4.63) |

[1] Adjusted for age, sex, ethnicity, smoking

[2] Adjusted for age, sex, ethnicity, smoking and all other exposure variables in the table

Ref = reference; # p<0.10; *p<0.05; **p<0.01