Received: 23 January 2023 | Revised: 13 June 2023 | Accepted: 19 June 2023

DOI: 10.1111/cod.14374

ORIGINAL ARTICLE

CONTACT DERMATITIS | WILEY

Prevalence of work-related skin symptoms and associated factors among tertiary hospital workers exposed to cleaning agents in Southern Africa

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Funding information
Allergy Society of South Africa; Millennium Promise Programme (University of Michigan/Fogarty International Center), Grant/Award Number: 1D43ES018744-01; National Research Foundation; South African Medical Research Council

Abstract

Introduction: Working with cleaning products is associated with occupational contact dermatitis in health workers (HWs), but information on predictors for these outcomes is limited.

Objectives: This study investigated the prevalence of work-related skin symptoms (WRSS) and associated factors in HWs exposed to cleaning agents in two Southern African tertiary hospitals.

Methods: A cross-sectional study of 697 HWs used an interviewer-administered questionnaire and assessed for atopy using Phadiatop.

Results: HWs' median age was 42 years, 77.0% were female and 42.5% were atopic. The prevalence of WRSS in the last 12 months was 14.8%, 12.3% had probable contact dermatitis (PCD) and 3.2% had probable contact urticaria (PCU). Technicians (OR_{adj} 3.91) and tasks involving cleaning and disinfection of skin wounds (OR_{adj} 1.98) were associated with WRSS in the past year. Factors associated with PCD included sterilizing instruments, disinfecting skin before procedures and use of wound adhesives. Factors associated with PCU included specimen preparation using formalin, medical instrument sterilization tasks, and skin/wound cleaning and disinfection. Appropriate glove use when performing patients' skin/wound care was protective against WRSS.

Conclusions: Tasks involving cleaning and disinfecting patients' skin and wounds were associated with WRSS in HWs, especially when performed without gloves.

KEYWORDS
cleaning agents, contact dermatitis, contact urticaria, health workers, skin symptoms, work-related

1 | INTRODUCTION

Occupational skin diseases (OSD) are an important cause of morbidity in the global workforce, but they are often under-diagnosed and under-reported.[1] Health workers (HWs) are at high risk of developing work-related skin symptoms (WRSS) and adverse skin-related health outcomes compared to the general working population.[2–5] Global epidemiological studies in HWs have reported the prevalence of

skin-related symptoms in the past year to be between 18.9% and 66%.[6] This is higher than the 1-year prevalence of hand dermatitis reported in the general population (9.1%).[7]

Host-related risk factors for occupational contact dermatitis (OCD)—particularly irritant contact dermatitis (ICD)—include younger age, female sex, a personal history of atopy and atopic dermatitis.[6] It has been suggested that the healthy worker effect and gendered distribution of work contribute to this pattern observed.[3] A history of allergy to any substance has been identified as a risk factor for allergic contact dermatitis (ACD) or ICD.[8,9]

The occupations commonly associated with OCD include those HWs in clinical roles (such as nursing and nursing auxiliary staff, medical, dental and surgical staff, allied health staff, and technologists) and in some non-clinical roles (such as hospital cleaning staff).[10,11] Workplace risk factors include cleaning agents, job tasks involving wet work, and lack of health and safety training.[6,9,12,13]

Common contemporary allergens associated with ACD and occasionally implicated in Type-I immediate hypersensitivity reactions include cleaning agents (instrument disinfectants such as glutaraldehyde [GTA] and ortho-phthalaldehyde [OPA], hand hygiene disinfectants such as chlorhexidine) and glove-related rubber chemicals.[11,14] Preservatives and excipients in cleaning agents have also been implicated.[15] With the substitution of less allergenic natural-rubber latex alternatives in gloves over time, the global incidence of latex allergy has declined.[16]

During outbreaks of disease such as COVID-19, HWs practise more intensive hand hygiene and surface disinfection, and use a wider range of personal protective equipment (PPE) more frequently for prolonged periods.[17–20] Increased HW complaints of PPE-related OSD, such as OCD, acne, contact urticaria, erosions, and pressure effects have been reported during such outbreaks.[17,19–21] Education and training on preventive measures and access to skin care products have been shown to have a protective effect against the development of OSD.[21]

There are few epidemiological studies on the prevalence and predictors of WRSS in HWs in the African health-care setting. This study aimed to assess the prevalence of skin symptoms and associated factors in HWs exposed to a variety of cleaning agents in two tertiary hospitals in Southern Africa.

2 | METHODS

2.1 | Study design, population, and sampling

This was a cross-sectional analytical study of HWs, which analysed data from a larger study collected between 2014 and 2018 in two tertiary academic hospitals in Southern Africa (i.e., South Africa and Tanzania). The original study investigated exposure to cleaning agents and reported on the prevalence of work-related asthma and associated factors in this group.[22] Ethical approval for this study was provided by the Human Research Ethics Committee (HREC) of the University of Cape Town (HREC Ref: 811/2021).

The World Health Organization (WHO) defines HWs as 'all people engaged in actions whose primary intent is to enhance health'.[23] This definition includes both health service providers who directly deliver healthcare services and health management and support workers who are indirectly involved in healthcare.[23] HWs in this study were considered to include both clinical and non-clinical staff categories in the healthcare sector, in keeping with the WHO definition, since HWs in both role types were reported to be at risk of OCD.

While a total of 699 permanently employed HWs working in high-risk departments were included in the larger study, 697 HWs (344 from the South African hospital and 353 from the Tanzanian hospital) that completed the questionnaire and had complete information on skin symptoms were included in the current study. Further information on these hospitals, including bed capacity and overall staff numbers can be found in Table S1. Written informed consent was obtained from participants in the appropriate official language prior to enrolment in the original study.

Stratified random sampling according to job title was used to select participants for incorporation into the study. Up to five HWs with the same job title per department were selected. The overall response rate was 53%, but a slightly higher response rate was observed for Tanzanian HWs (TAHWs) (63%) compared to South African HWs (SAHWs) (46%).

2.2 | Health outcome assessments

2.2.1 | Questionnaire

Trained interviewers administered questionnaires in English for SAHWs and in Swahili for TAHWs. The questionnaires were validated for repeatability through back-translation of the original questionnaire.

The questionnaire used was a modified version of the European Community Respiratory Health Survey[24] and included questions from the validated National Institute for Occupational Safety and Health questionnaire for cleaning agents in the health care setting.[25] It gathered information on demographic features, medical history, occupational characteristics, the nature and duration of exposure to cleaning agents, workplace control measures, and presence of skin and respiratory symptoms. The occurrence of general skin symptoms within the past 12 months was characterized by its distribution ('hands/forearm' or 'whole body') and clinical features ('itchy or scratchy skin', 'hives', 'dry, scaly skin', 'redness of the skin', 'blisters or weeping skin', 'burning skin", "rash within an hour of contact with a rubber latex product"). The presence of work-related skin symptoms (WRSS) was also assessed, both in relation to symptoms within the last 12 months, and suspected workplace triggers focusing on cleaning agents.

2.2.2 | Immunological tests

A blood specimen was drawn from 682 participants (339 working in the South African hospital and 343 from the Tanzanian hospital) for quantification of IgE to a mixture of 23 common aeroallergens

(Phadiatop), which includes mites (*Dermatophagoides pteronyssinus* and *Dermatophagoides farinae*), pets (cat and dog), mixed moulds (*Penicillium*, *Cladosporium*, *Aspergillus*, and *Alternaria*), mixed grasses (*Parietaria*, *Lolium*, *Phleum*, and *Cynodon*), *Artemisia* and mixed tree species (*Acer*, *Betula*, *Ulmus*, *Quercus*, *Olea*, *Salix*, *Pinus*, *Eucalyptus*, *Acacia*, and *Malaleuca*).[26] An ImmunoCAP result of >0.35 kU/L was regarded as positive for atopy.

2.2.3 | Operational definitions

The following operational definitions were generated:

Probable contact dermatitis: Having two or more skin symptoms in the last 12 months affecting hands (itchy/scratchy, dry/scaly, redness, blisters/weeping, burning skin).

Probable contact urticaria: Having self-reported either hives or rash within 1 h of contact with a rubber latex product.

Work-related skin symptoms ever: Responding 'yes' to the question 'Does being at work ever cause you to have skin problems?'. Synonymous with a lifetime history of work-related skin symptoms.

> **Definition 1.** *Work-related skin symptoms in the past year*: A more sensitive definition in which HWs experienced WRSS at any time within the last 12 months. (Participants indicated that they experienced skin problems caused by work and while at work within the last 12 months.)

> **Definition 2.** *Work-related skin symptoms in the past year*: A more specific definition in which HWs experienced WRSS that improved away from work or worsened on return to work within the last 12 months. (Participants indicated that they experienced skin problems within the last 12 months that were (a) caused by work, (b) occurred while at work, (c) improved away from work and/or worsened on return to work.)

2.3 | Data analysis

RStudio (URL: http://www.rstudio.com/), RRID:SCR_000432 was used for all analyses. The prevalence of exposures and adverse skin outcomes (WRSS, probable urticaria, and probable contact dermatitis) was computed and compared between the two hospitals. Bivariate analysis with unadjusted logistic regression models was used to assess associations between host-related (age, gender, atopy, personal or family history of allergy, and domestic cleaning habits) and occupational factors (work activities and tasks, cleaning agents, glove usage, and training) in relation to skin outcomes. Multivariate saturated logistic regression models were developed and adjusted for family history of allergy, personal domestic cleaning of more than once per week, and hospital facility since significant associations were observed between these exposures and skin outcomes. A second set of multivariate logistic regression models that included age, gender and atopy were developed but no differences in the effect estimates were observed.

3 | RESULTS

3.1 | Study population

The median age of participants was 42 years, 77% were female having a median employment duration of 14 years (Table 1). The prevalence of atopy was 42.5%, but a much lower prevalence of a personal history of atopic dermatitis (3.2%) was reported. Overall, SAHWs were significantly older having a higher prevalence of atopy, family history of allergy, atopic dermatitis and domestic chemical use. However, TAHW's reported a higher prevalence of history of allergy to specific agents (insect bites or stings, foods, medication or latex).

The majority of participants (75.5%) were nursing professionals and a smaller group were cleaners (12.2%). Study subjects were commonly working in operating theatres (29.8%) and intensive care units (24.8%) (Table S1).

Most HWs personally cleaned their own homes ≥1 times/week (Table 1)—more prevalent among SAHWs (95.1%) than TAHWs (77.6%). Among these HWs, SAHWs commonly used ammonia-based (89.8%) and chlorine-based products (78.5%) compared to TAHWs that only used chlorine-based products (23.2%).

3.2 | Skin symptoms

Skin symptoms in the past 12 months were present in 17.9% of HWs and were more common among SAHWs (23.8%) compared to TAHWs (12.3%) (Table 1). The most prevalent localized hand symptoms were itching or scratchiness (10.3%), redness (6.5%) and burning skin (3.4%). The prevalence of probable contact dermatitis (PCD) was 12.3% compared to probable contact urticaria (PCU) of 3.2%.

A total of 130 participants (18.7%) reported WRSS in their lifetime, 14.8% reported WRSS within the last 12 months (Definition 1), and 11.5% reported more specific WRSS within the last 12 months (Definition 2). Very few participants reported doctor-diagnosed work-related skin disease (2.9%).

HWs reported chlorhexidine (15.7%), latex (2.7%), bleach (2.4%), liquid soap (1.6%), and OPA (1.0%) as the top five chemical triggers for their skin symptoms. Notably, TAHWs did not use chlorhexidine.

3.3 | Host factors associated with skin outcomes

In the unadjusted logistic regression models (Table S2 and S3), a personal history of allergy to any substance (including insect bites or stings, foods, medication or latex) was associated with an increased odds of PCU (OR = 3.29, 95% CI 1.37–8.73), PCD (OR = 1.74, 95% CI 1.11–2.75) and WRSS in the past 12 months (Definition 1:

TABLE 1 Prevalence of host-related and occupational characteristics, and skin symptoms among health workers in the two tertiary hospitals.

	SAHWs *n* (%) *n* = 344	TAHWs *n* (%) *n* = 353	Total *N* (%) *N* = 697	*p*-Value (chi-squared test)
Host-related characteristics				
Age (years) [median (IQR)]	46 (33–51)	39 (31–51)	42 (32–51)	**0.010***
Gender (%F:M)	84:16	71:29	77:23	**<0.001**
Family history of allergy	219 (63.7)	134 (38.0)	353 (50.6)	**<0.001**
Atopy (Phadiatop positive)	160 (46.5)	136 (38.5)	296 (42.5)	**0.048**
History of allergy to any agent (including insect bites or stings, foods, medication, or latex)	97 (28.2)	167 (47.3)	264 (37.9)	**<0.001**
History of atopic dermatitis	18 (5.2)	4 (1.1)	22 (3.2)	**0.004**
Frequency of personally cleaning home (≥ 1 day/week)	327 (95.1)	274 (77.6)	601 (86.2)	**<0.001**
Domestic cleaning products used				
Chlorine based (≥1 day/week)	270 (78.5)	82 (23.2)	352 (50.5)	**<0.001**
Ammonia based (≥1 day/week)	309 (89.8)	0 (0.0)	309 (44.3)	**<0.001**
Window cleaners (≥1 day/week)	43 (12.5)	0 (0.0)	43 (6.2)	**<0.001**
Occupational characteristics				
Job title				
Nursing:	239 (69.5)	287 (81.3)	526 (75.5)	**<0.001**
Registered professional nurse	132 (38.4)	151 (42.8)	283 (40.6)	
Nurse assistant/health attendant	59 (17.2)	109 (30.9)	168 (24.1)	
Enrolled nurse	48 (14.0)	27 (7.7)	75 (10.8)	
Cleaner	45 (13.1)	40 (11.3)	85 (12.2)	
Clerk/administrative	13 (3.8)	25 (7.1)	38 (5.5)	
Technician	33 (9.6)	1 (0.3)	34 (4.9)	
Porter	14 (4.1)	-	-	
Employment history				
Total years in healthcare industry [median (IQR)]	20 (8–28)	11 (4–27)	14 (6–28)	**<0.001***
Total years in current job [median (IQR)]	4 (1–11)	4 (2–8)	4 (2–9)	0.862*
Previous health work in other departments in current hospital (yes vs. no)	337 (98.0)	195 (55.2)	532 (76.3)	**<0.001**
Skin symptoms				
Two or more skin symptoms in the last 12 months	82 (23.8)	43 (12.3)	125 (17.9)	**<0.001**
Itchy/scratchy skin affecting hands	40 (11.6)	32 (9.1)	72 (10.3)	0.324
Redness of the skin affecting hands	34 (9.8)	11 (3.1)	45 (6.5)	0.567
Burning skin affecting hands	22 (6.4)	2 (0.6)	24 (3.4)	**<0.001**
Hives affecting hands	9 (2.6)	6 (1.7)	15 (2.2)	0.720
Blisters or weeping skin affecting hands	6 (1.7)	4 (1.1)	10 (1.4)	**<0.001**
Rash within an hour of contact with a rubber latex product affecting hands	7 (2.0)	1 (0.3)	8 (1.2)	0.070
Dry, scaly skin affecting hands	0 (0.0)	7 (2.0)	7 (1.0)	**0.025**
Probable contact dermatitis[a]	50 (14.5)	36 (10.2)	86 (12.3)	0.104
Probable contact urticaria[b]	16 (4.7)	6 (1.7)	22 (3.2)	**0.044**
Lifetime history of WRSS (WRSS ever)	95 (27.6)	35 (9.9)	130 (18.7)	**<0.001**
WRSS in the last 12 months (Definition 1)	76 (22.1)	27 (7.7)	103 (14.8)	**<0.001**
WRSS in the last 12 months (Definition 2)	61 (17.7)	19 (5.4)	80 (11.5)	**<0.001**
Doctor diagnosed work-related skin disease	16 (4.7)	4 (1.1)	20 (2.9)	0.628

Note: Bold values represent statistically significant results.

Abbreviations: IQR, interquartile range, F, female; M, male; SAHWs, South African health workers; TAHWs, Tanzanian health workers; WRSS, work-related skin symptoms.

[a]Two or more skin symptoms in the last 12 months, affecting hands with itchy/scratchy skin, or dry/scaly skin, or redness of the skin, or blisters/weeping skin, or burning skin.

[b]Self-reported hives or rash within 1 h of contact with a rubber latex product.

*Wilcoxon rank sum test.

OR = 1.95, 95% CI 1.28–2.99; Definition 2: OR = 2.20, 95% CI 1.38–3.55). Furthermore, work-related skin outcomes were also associated with an increased odds of a family history of allergy.

Personal domestic cleaning chores ≥1 times/week was significantly associated with WRSS in the past 12 months (Definition 2: OR = 3.33, 95% CI 1.34–11.11). The use of chlorine-based cleaning agents at home ≥1 times/week was associated with an increased odds of burning skin of the hands. Using ammonia-based cleaning agents at home ≥1 times/week was associated with an increased likelihood of WRSS, redness and burning affecting hands, rash within an hour of contact with a rubber latex product, PCU and PCD.

3.4 | Occupational factors associated with skin outcomes

In the multivariate logistic regression models, an approximately four-fold increased odds of WRSS and PCD was found in technicians compared to administrative clerks (Table 2).

Workers with PCU were more likely to use hydrogen peroxide for medical instrument cleaning and disinfection (OR_{adj} = 3.95, 95% CI: 1.08–11.55) and formalin 10% for specimen preparation (OR_{adj} = 2.50, 95% CI: 1.03–6.09) (Table 3). Job tasks associated with an increased likelihood of PCU included manual and automatic sterilization of medical instruments, and disinfection of patients' skin areas prior to procedures.

A protective association against PCD was observed among HWs using alcohol sanitiser to clean hands (OR_{adj} = 0.29, 95% CI: 0.07–0.83). Job tasks associated with an increased likelihood of PCD included manual sterilization of medical instruments, disinfection of patients' skin areas prior to procedures and the use of wound adhesives.

Among the workplace activities, patients' skin/wound cleaning and disinfection significantly increased the odds of WRSS (Definition 2: OR_{adj} = 1.98, 95% CI: 1.16–3.48). Except for cleaning and disinfecting wounds, all the job tasks that involved patients' skin/wound cleaning and disinfection were associated with an approximately two-fold increased likelihood of WRSS. Automatic sterilization of medical instruments was also associated with an increased odds of WRSS in the past 12 months (Definition 1: OR_{adj} = 3.80, 95% CI: 1.34–10.80).

In contrast to SAHWs, a protective association for WRSS (Definition 1: OR_{adj} = 0.41, 95% CI: 0.18–0.92) was observed for TAHWs using liquid hand soap. Protective associations were also observed for WRSS in the last 12 months when using bleach or all-purpose cleaner for medical instruments cleaning and disinfection.

TABLE 2 Association between occupational factors in relation to work-related skin outcomes in adjusted logistic regression models.

Adjusted odds ratio (95% confidence interval)					
	Probable contact urticaria (*n* = 22)	**Probable contact dermatitis (*n* = 86)**	**WRSS ever (*n* = 130)**	**WRSS in the last 12 months (Defn. 1) (*n* = 103)**	**WRSS in the last 12 months (Defn. 2) (*n* = 80)**
Job title					
Clerk/administrative	Reference	Reference	Reference	Reference	Reference
Nursing (*n* = 526)	0.46 (0.12–3.03)	1.14 (0.43–3.92)	1.70 (0.64–5.91)	1.27 (0.47–4.42)	1.31 (0.44–5.65)
Registered professional nurse (*n* = 283)	0.48 (0.11–3.30)	1.27 (0.47–4.47)	2.06 (0.76–7.23)	1.62 (0.59–5.70)	1.56 (0.51–6.83)
Nursing assistant (*n* = 168)	0.29 (0.04–2.28)	0.83 (0.28–3.05)	1.27 (0.44–4.66)	0.93 (0.31–3.47)	1.14 (0.34–5.22)
Enrolled nurse (*n* = 75)	0.74 (0.13–5.65)	1.35 (0.42–5.22)	1.39 (0.44–5.34)	0.81 (0.24–3.24)	0.83 (0.21–4.12)
Cleaner (*n* = 85)	0.16 (0.01–1.73)	0.73 (0.20–2.95)	1.34 (0.43–5.10)	0.78 (0.23–3.12)	0.69 (0.17–3.50)
Technician (*n* = 34)	1.11 (0.16–9.36)	**4.85 (1.65–14.26)****	2.24 (0.89–5.58)	**2.95 (1.08–8.08)***	**3.91 (1.28–11.97)***
Porter (*n* = 14)	NC	NC	0.38 (0.02–2.95)	0.38 (0.02–2.97)	NC
Employment history					
Duration in health work	1.00 (0.96–1.03)	1.01 (0.99–1.03)	1.01 (0.99–1.03)	1.01 (0.99–1.03)	1.00 (0.98–1.02)
Duration in current department	1.01 (0.95–1.07)	1.01 (0.98–1.04)	1.02 (1.00–1.05)	1.02 (0.99–1.04)	1.02 (0.99–1.05)

Note: Data are presented as OR (95% CI), unless otherwise indicated. Each OR represents a separate regression model adjusted for host-related factors (family history of allergy to any substance and personal domestic cleaning frequency ≥1 time/week) and hospital facility.
Defn. 1: WRSS at any time within the last 12 months.
Defn. 2: WRSS that improved away from work or worsened on return to work within the last 12 months.
Abbreviations: CI, confidence interval; NC, not calculable; OR, odds ratio; WRSS, work-related skin symptoms.
*p-Value <0.05; **p-Value <0.01.

TABLE 3 Association between nature of occupational exposures in relation to work-related skin outcomes in adjusted logistic regression models.

Adjusted odds ratio (95% confidence interval)					
	Probable contact urticaria ($n = 22$)	**Probable contact dermatitis ($n = 86$)**	**WRSS ever ($n = 130$)**	**WRSS in the last 12 months (Defn. 1) ($n = 103$)**	**WRSS in the last 12 months (Defn. 2) ($n = 80$)**
Wet work					
Handwash frequency ≥ 10 times/day ($n = 642$)	NC	1.59 (0.60–5.47)	0.82 (0.36–2.11)	0.71 (0.29–2.01)	0.60 (0.23–1.90)
Workplace activity					
Hand washing/sanitizing ($n = 697$)	NC	NC	NC	NC	NC
Fixed surfaces cleaning and disinfection ($n = 572$)	1.50 (0.39–9.86)	0.98 (0.53–1.91)	1.12 (0.62–2.13)	0.96 (0.51–1.92)	1.49 (0.68–3.74)
Patients' skin/wound cleaning and disinfection ($n = 327$)	2.32 (0.87–6.97)	1.44 (0.87–2.39)	**1.77 (1.15–2.77)***	**2.14 (1.32–3.53)****	**1.98 (1.16–3.48)***
Medical instruments cleaning and disinfection ($n = 301$)	1.69 (0.71–4.11)	0.92 (0.58–1.46)	0.95 (0.64–1.42)	0.73 (0.46–1.13)	0.71 (0.43–1.16)
Specimen preparation ($n = 157$)	2.26 (0.90–5.49)	0.96 (0.55–1.64)	0.94 (0.59–1.48)	0.81 (0.48–1.34)	0.57 (0.30–1.02)
Cleaning agent use (by workplace activity)					
Medical instruments cleaning and disinfection					
Enzymatic cleaners ($n = 113$)	1.85 (0.64–4.70)	1.03 (0.55–1.85)	1.58 (0.96–2.54)	0.91 (0.50–1.58)	0.63 (0.30–1.22)
Ortho-phthalaldehyde ($n = 113$)	2.28 (0.84–5.67)	1.33 (0.73–2.33)	1.25 (0.75–2.04)	1.03 (0.58–1.77)	0.76 (0.38–1.42)
Chlorhexidine ($n = 84$)	1.08 (0.29–3.22)	0.97 (0.46–1.91)	0.96 (0.55–1.66)	0.93 (0.50–1.67)	1.10 (0.57–2.03)
Hydrogen peroxide ($n = 40$)	**3.95 (1.08–11.55)***	1.79 (0.74–3.88)	1.20 (0.51–2.59)	1.16 (0.45–2.63)	1.00 (0.33–2.51)
Bleach ($n = 204$)	1.28 (0.44–3.32)	0.77 (0.44–1.32)	0.60 (0.36–1.00)	**0.41 (0.21–0.75)***	**0.49 (0.24–0.93)***
All-purpose cleaner ($n = 132$)	0.85 (0.12–4.45)	0.81 (0.38–1.66)	0.50 (0.20–1.09)	**0.20 (0.05–0.60)***	**0.20 (0.03–0.70)**
Glutaraldehyde ($n = 49$)	1.21 (0.06–7.18)	0.74 (0.21–1.96)	1.17 (0.42–2.81)	0.20 (0.03–1.50)	0.29 (0.02–1.44)
Fixed surfaces cleaning and disinfection					
Bleach ($n = 474$)	0.56 (0.23–1.40)	0.87 (0.54–1.42)	1.10 (0.72–1.73)	1.00 (0.63–1.63)	1.38 (0.80–2.46)
Ammonia ($n = 73$)	0.51 (0.08–1.88)	1.37 (0.67–2.69)	0.81 (0.44–1.46)	0.88 (0.45–1.63)	0.78 (0.37–1.54)
Dishwashing liquid ($n = 138$)	1.44 (0.51–4.04)	1.10 (0.59–2.03)	0.93 (0.57–1.51)	0.90 (0.52–1.51)	0.82 (0.45–1.45)
All-purpose cleaner ($n = 202$)	0.76 (0.14–4.16)	0.93 (0.46–1.88)	0.86 (0.43–1.76)	0.66 (0.30–1.46)	1.01 (0.40–2.68)
Enzymatic cleaners ($n = 42$)	1.35 (0.21–4.93)	1.64 (0.68–3.53)	1.66 (0.78–3.36)	1.25 (0.51–2.72)	1.16 (0.42–2.74)
Specimen preparation					
Formalin 10% solution ($n = 148$)	**2.50 (1.03–6.09)***	0.99 (0.56–1.69)	0.92 (0.57–1.46)	0.81 (0.47–1.35)	0.59 (0.31–1.08)
Patients' skin/wound cleaning and disinfection					
Chlorhexidine ($n = 65$)	2.09 (0.64–6.01)	1.44 (0.68–2.87)	1.07 (0.58–1.93)	1.29 (0.67–2.37)	1.48 (0.75–2.81)
Povidone iodine ($n = 49$)	2.00 (0.54–6.07)	0.98 (0.38–2.21)	1.33 (0.68–2.53)	1.17 (0.56–2.33)	1.06 (0.46–2.25)
Hand washing/sanitizing					
Chlorhexidine ($n = 337$)	NC	NC	0.51 (0.11–2.63)	0.72 (0.15–5.08)	0.53 (0.11–3.80)
Liquid hand soap South Africa ($n = 305$)	1.85 (0.35–34.06)	2.22 (0.76–9.47)	1.28 (0.60–2.98)	1.30 (0.58–3.35)	0.97 (0.42–2.51)
Alcohol sanitiser ($n = 79$)	0.71 (0.04–4.48)	**0.29 (0.07–0.83)***	0.55 (0.18–1.35)	0.26 (0.06–1.11)	0.39 (0.06–1.40)
All-purpose cleaner (diluted) ($n = 153$)	2.51 (0.48–18.46)	1.77 (0.88–3.61)	1.08 (0.53–2.19)	1.96 (0.88–4.49)	0.93 (0.35–2.38)
Hand wash liquid soap Tanzania ($n = 235$)	0.24 (0.03–1.32)	0.73 (0.35–1.57)	0.72 (0.35–1.50)	**0.41 (0.18–0.92)***	0.75 (0.29–2.01)
Job task (by workplace activity)					

(Continues)

TABLE 3 (Continued)

Adjusted odds ratio (95% confidence interval)	Probable contact urticaria ($n = 22$)	Probable contact dermatitis ($n = 86$)	WRSS ever ($n = 130$)	WRSS in the last 12 months (Defn. 1) ($n = 103$)	WRSS in the last 12 months (Defn. 2) ($n = 80$)
Medical instruments cleaning and disinfection					
Manually disassemble instruments or remove gross contaminants ($n = 202$)	1.29 (0.50–3.11)	1.14 (0.69–1.85)	1.14 (0.74–1.73)	1.08 (0.68–1.71)	1.04 (0.61–1.72)
Prepare cleaning solutions (diluting or mixing) ($n = 251$)	0.80 (0.31–1.93)	0.85 (0.52–1.38)	1.00 (0.66–1.50)	0.77 (0.49–1.21)	0.89 (0.54–1.46)
Change sterilizing solutions ($n = 157$)	0.76 (0.22–2.11)	0.68 (0.36–1.20)	0.94 (0.58–1.49)	0.67 (0.38–1.13)	0.56 (0.28–1.03)
Manually sterilize or high-level disinfect ($n = 143$)	**2.89 (1.15–7.16)***	**1.80 (1.06–3.02)***	1.52 (0.97–2.38)	1.34 (0.82–2.18)	1.18 (0.68–2.02)
Sterilize instruments with automated systems ($n = 16$)	**6.10 (1.27–22.49)***	2.85 (0.86–8.26)	2.74 (0.97–7.74)	**3.80 (1.34–10.80)***	2.15 (0.65–6.21)
Fixed surfaces cleaning and disinfection					
Use more wipes vs. more sprays ($n = 452$)	1.50 (0.61–4.06)	1.20 (0.74–1.98)	0.86 (0.57–1.30)	0.81 (0.52–1.26)	0.82 (0.51–1.35)
Manually mix, refill, or empty cleaning/disinfecting products ($n = 353$)	0.46 (0.18–1.17)	0.96 (0.58–1.59)	1.08 (0.70–1.68)	0.99 (0.62–1.59)	1.09 (0.65–1.87)
Clean instruments or equipment ($n = 403$)	2.48 (0.84–9.13)	1.10 (0.66–1.83)	1.10 (0.70–1.73)	1.34 (0.82–2.24)	1.56 (0.89–2.82)
Terminal cleaning of patient rooms ($n = 155$)	0.56 (0.17–1.56)	0.76 (0.41–1.37)	0.69 (0.42–1.11)	0.81 (0.48–1.35)	1.06 (0.60–1.83)
Clean up blood and spills ($n = 377$)	0.55 (0.22–1.39)	1.26 (0.77–2.09)	1.11 (0.72–1.72)	0.94 (0.59–1.51)	1.05 (0.62–1.79)
Clean bathrooms ($n = 104$)	0.27 (0.02–1.34)	0.48 (0.20–1.01)	0.69 (0.36–1.24)	0.54 (0.24–1.07)	0.47 (0.18–1.04)
Patients' skin / wound cleaning and disinfection					
Disinfect skin areas on patients prior to procedure ($n = 251$)	**2.58 (1.05–6.81)***	**2.19 (1.35–3.56)****	**1.58 (1.05–2.38)***	**2.06 (1.32–3.24)****	**1.83 (1.11–3.02)***
Clean and disinfect wounds ($n = 161$)	1.01 (0.36–2.63)	0.98 (0.55–1.69)	0.97 (0.60–1.53)	1.10 (0.66–1.79)	1.45 (0.85–2.47)
Apply wound dressing ($n = 143$)	1.23 (0.44–3.19)	1.29 (0.73–2.25)	1.27 (0.79–2.01)	1.43 (0.86–2.34)	**1.89 (1.10–3.22)***
Use adhesives ($n = 277$)	2.58 (0.98–7.53)	**1.80 (1.08–3.02)***	**1.99 (1.29–3.08)****	**2.62 (1.62–4.32)****	**2.65 (1.55–4.67)****
Use adhesive removing solvents ($n = 196$)	1.72 (0.61–5.46)	1.16 (0.64–2.15)	1.12 (0.70–1.82)	1.39 (0.83–2.36)	**2.03 (1.13–3.74)***

Note: Data are presented as OR (95% CI), unless otherwise indicated. Each OR represents a separate regression model adjusted for host-related factors (family history of allergy to any substance and personal domestic cleaning frequency ≥1 time / week) and hospital facility; Reference group of comparison are workers not using the chemical or performing the task.

Abbreviations: CI, confidence interval; NC: not calculable; OR, odds ratio; WRSS, work-related skin symptoms.

*p-Value < 0.05; **p-Value < 0.01

3.5 | Duration and frequency of occupational exposures and skin outcomes

HWs with PCU were more likely to work with chemical agents used for fixed surfaces cleaning and disinfection ($OR_{adj} = 4.18$, 95% CI: 1.54–12.46) and specimen preparation ($OR_{adj} = 3.89$, 95% CI: 1.55–9.44) for 1–99 min per week (Table 4). Similarly, the odds were increased for performing job tasks that involved patients' skin/wound cleaning and disinfection ($OR_{adj} = 5.55$, 95% CI: 2.11–15.51) ≥100 min/week or any exposure duration for tasks involving fixed surfaces cleaning and disinfection. A higher frequency of chemical agent exposure for specimen preparation and patients' skin/wound cleaning and disinfection was also associated with an increased likelihood of PCU.

TABLE 4 Association between duration and frequency of occupational exposures in relation to work-related skin outcomes in adjusted logistic regression models.

Adjusted odds ratio (95% confidence interval)					
	Probable Contact Urticaria ($n = 22$)	**Probable contact dermatitis ($n = 86$)**	**WRSS ever ($n = 130$)**	**WRSS in the last 12 months (Defn. 1) ($n = 103$)**	**WRSS in the last 12 months (Defn. 2) ($n = 80$)**
Duration of chemical agent exposure by work activity					
Specimen preparation					
1–99 min/week	**3.89 (1.55–9.44)****	1.31 (0.71–2.29)	1.13 (0.66–1.87)	1.67 (0.08–13.20)	0.80 (0.39–1.50)
≥100 min/week	NC	NC	1.26 (0.06–9.90)	1.02 (0.56–1.78)	NC
Patients' skin/wound cleaning and disinfection					
1–99 min/week	1.84 (0.49–5.66)	1.26 (0.54–2.69)	0.73 (0.35–1.42)	0.91 (0.42–1.83)	1.26 (0.58–2.56)
≥100 min/week	1.33 (0.07–7.57)	1.47 (0.40–4.26)	1.51 (0.57–3.76)	1.73 (0.63–4.40)	1.45 (0.45–3.95)
Duration of job task exposure by work activity					
Patients' skin/wound cleaning and disinfection					
1–99 min/week	1.97 (0.50–6.80)	0.86 (0.42–1.64)	1.28 (0.75–2.13)	1.27 (0.70–2.23)	1.11 (0.57–2.06)
≥100 min/week	**5.55 (2.11–15.51)****	1.61 (0.92–2.77)	1.56 (0.94–2.54)	**1.78 (1.04–3.00)***	1.42 (0.77–2.54)
Frequency of chemical exposure by work activity					
Specimen preparation (days/week)	**1.29 (1.04–1.55)***	1.03 (0.87–1.19)	1.06 (0.92–1.21)	1.05 (0.89–1.21)	0.93 (0.75–1.12)
Patients' skin/wound cleaning and disinfection (days/week)	**1.26 (1.01–1.55)***	1.06 (0.91–1.23)	1.03 (0.90–1.16)	1.06 (0.93–1.21)	1.07 (0.92–1.23)
Frequency of job task exposure by work activity					
Patients' skin/wound cleaning and disinfection					
Days/week	**1.37 (1.12–1.69)****	1.08 (0.96–1.20)	1.09 (0.99–1.21)	**1.12 (1.00–1.24)***	1.08 (0.95–1.21)
Times/day	**1.12 (1.04–1.19)****	1.03 (0.97–1.08)	1.02 (0.97–1.07)	1.04 (0.99–1.09)	1.01 (0.95–1.07)

Note: Data are presented as OR (95% CI), unless otherwise indicated. Each OR represents a separate regression model adjusted for host-related factors (family history of allergy to any substance and personal domestic cleaning frequency ≥1 time/week) and hospital facility. Reference group of comparison are workers not using the chemical or performing the task.

Abbreviations: CI, confidence interval; NC, not calculable; OR, odds ratio; WRSS, work-related skin symptoms.

*p-Value < 0.05; **p-Value < 0.01.

Job tasks of ≥100 min/week duration for patients' skin/wound cleaning and disinfection were associated with a one-year history of WRSS (Definition 1). Furthermore, HWs exposed more frequently to job tasks involving patients' skin cleaning and disinfection had an increased odds of WRSS within the past 12 months. These findings were indicative of a dose–response relationship.

3.6 | Association between glove usage, training, and skin outcomes

As demonstrated in Table 5, the use of gloves when performing manual or automated sterilization tasks was associated with an increased likelihood of PCU and PCD. Automated sterilization tasks were also associated with an increased lifetime and 1-year history of WRSS.

For patients' skin or wound cleaning and disinfection, however, the use of gloves was protective against the presence of WRSS, both in the HWs lifetime ($OR_{adj} = 0.32$, 95% CI: 0.10–0.94) and in the last 12 months (Definition 1: $OR_{adj} = 0.23$, 95% CI: 0.07–0.70). It also reduced the likelihood of PCD among those HWs who performed job tasks involving disinfection of patients' skin prior to procedures, as well as cleaning and disinfecting wounds.

Receiving training on protection against the adverse health effects of working with cleaning agents was protective but was not significantly associated with the relevant skin problems among these HWs.

4 | DISCUSSION

This is the first epidemiological study, to our knowledge, that has reported on the prevalence and factors associated with WRSS, contact urticaria, and contact dermatitis in HWs exposed to diverse cleaning agents in African settings. Cleaning and disinfection of patients' skin and wounds were identified as a work activity associated with WRSS, with a consistent trend observed for job tasks related to this work. Furthermore, a suggestive dose–response relationship was observed between WRSS and duration or frequency of exposure.

TABLE 5 Association between glove usage practices and training in relation to skin outcomes in adjusted logistic regression models.

Adjusted odds ratio (95% confidence interval)					
	Probable contact Urticaria ($n = 22$)	**Probable contact Dermatitis ($n = 86$)**	**WRSS ever ($n = 130$)**	**WRSS in the last 12 months (Defn. 1) ($n = 103$)**	**WRSS in the last 12 months (Defn. 2) ($n = 80$)**
Glove usage for medical instruments cleaning and disinfection ($n = 321$)	1.10 (0.45–2.73)	0.90 (0.56–1.44)	0.99 (0.66–1.50)	0.85 (0.55–1.34)	0.92 (0.56–1.51)
Manually disassemble instruments or remove gross contaminants ($n = 195$)	1.37 (0.53–3.31)	1.07 (0.64–1.75)	1.12 (0.73–1.71)	1.04 (0.65–1.65)	1.04 (0.61–1.72)
Prepare cleaning solutions (diluting or mixing) ($n = 232$)	0.77 (0.29–1.88)	0.84 (0.50–1.36)	0.96 (0.63–1.45)	0.69 (0.43–1.09)	0.80 (0.47–1.31)
Change sterilizing solutions ($n = 149$)	0.83 (0.24–2.29)	0.75 (0.40–1.31)	1.01 (0.62–1.61)	0.70 (0.39–1.19)	0.63 (0.32–1.16)
Manually sterilize or high-level disinfect ($n = 141$)	**2.94 (1.17–7.30)***	**1.72 (1.00–2.89)***	1.48 (0.94–2.32)	1.29 (0.78–2.10)	1.12 (0.64–1.92)
Sterilize instruments with automated systems ($n = 13$)	**8.15 (1.66–31.66)****	**3.99 (1.16–12.54)***	**4.23 (1.37–14.36)***	**5.84 (1.88–19.90)****	2.87 (0.84–8.96)
Patients' skin / wound cleaning and disinfection ($n = 218$)	0.51 (0.10–3.70)	0.34 (0.10–1.24)	**0.32 (0.10–0.94)***	**0.23 (0.07–0.70)***	0.40 (0.13–1.32)
Disinfect skin areas on patients prior to procedure ($n = 148$)	0.34 (0.04–7.45)	**0.08 (0.01–0.48)***	0.4 (0.07–2.32)	0.33 (0.05–1.93)	0.47 (0.08–3.74)
Clean and disinfect wounds ($n = 60$)	NC	**0.03 (0.00–0.98)***	0.25 (0.01–7.05)	0.13 (0.00–3.99)	0.11 (0.00–3.33)
Apply wound dressing ($n = 61$)	NC	NC	NC	NC	NC
Use adhesives ($n = 153$)	0.67 (0.19–2.71)	0.94 (0.34–2.86)	0.54 (0.23–1.25)	**0.40 (0.17–0.96)***	0.43 (0.17–1.07)
Use adhesive removing solvents ($n = 84$)	4.03 (0.71–75.97)	2.64 (0.81–11.95)	1.11 (0.47–2.75)	1.09 (0.44–2.93)	0.99 (0.38–2.81)
Training on adverse health effects due to cleaning agents ($n = 218$)	0.39 (0.09–1.18)	0.88 (0.52–1.46)	0.81 (0.51–1.27)	0.60 (0.35–1.01)	0.65 (0.35–1.15)

Note: Data are presented as OR (95% CI), unless otherwise indicated. Each OR represents a separate regression model adjusted for host-related factors (family history of allergy to any substance and personal domestic cleaning frequency ≥1 time/week) and hospital facility. Reference group of comparison are workers not performing the task.

Abbreviations: CI, confidence interval; NC, not calculable; OR, odds ratio; WRSS, work-related skin symptoms.

*p-Value <0.05; **p-Value <0.01.

Glove use when performing this work activity, however, was protective for WRSS, thus reinforcing the importance of PPE.

The overall 1-year prevalence of WRSS in the current study (12%–15%) was at the lower end of the range reported in studies of HWs globally (18.9%–66%).[6] Since they were still employed in healthcare, an underestimation due to 'healthy worker' bias is possible. The absence of an association between duration of employment and WRSS further supports this assertion. It is also likely that this low-end prevalence observed is related to different definitions and methods for assessment of WRSS used between studies. The 1-year prevalence of PCU was much lower (3.2%) but to our knowledge, there were no other studies reported for comparative purposes. The prevalence of PCU and WRSS differed significantly between hospitals and it is likely that this was influenced by a number of factors that differed between the two hospitals, such as the varying policies and work practices within the high-risk departments, chemical usage, and control measures (including glove usage) (Table S1). It should be noted that these results depict the situation preceding the COVID-19 pandemic and it is probable that the prevalence of OSD in HWs since 2020 will be higher due to more stringent hygiene practices, increased

use of disinfectants and changes in PPE usage protocols during infectious disease outbreaks.[17–20]

The prevalence of doctor-diagnosed work-related skin disease was very low in this study. This may be due to multiple factors including under-reporting, under-diagnosis and under-compensation.[2–4] This is compounded by downstream behavioural factors, such as decisions by workers not to report or treat minor symptoms, as well as upstream factors such as the lack of access to comprehensive occupational health services.[3]

In this present study, a personal or family history of allergy was important host-related factor associated with WRSS. A family history of allergy has been reported as a risk factor for personal allergy[27] and the latter has previously been identified as a risk factor for WRSS.[28] However, unlike previous studies,[4,5,29] atopy and atopic dermatitis were not shown to be significant factors associated with WRSS in the present study.

Working as a technician was identified as an occupation at increased likelihood of having PCD and WRSS. Technicians in most published reports on OSD in HWs were laboratory technicians or dental technicians, and evidence of OSD among hospital technicians has not been widely reported. In contrast to other studies,[8,10,11] working in a nursing or cleaner role was not significantly associated with WRSS. The technicians assessed in this study were few in number and further epidemiological research is therefore necessary to identify at-risk occupations among HWs.

In this study, glove use during cleaning and disinfecting patients' skin or wounds and related tasks was protective against WRSS and PCD. In contrast, glove usage during manual and automatic sterilization tasks was significantly associated with PCU and PCD. The associations between these job tasks (with gloves) and adverse skin outcomes were stronger than for the job task alone (without gloves). Despite the well-known benefits of glove use in healthcare settings, they may cause skin problems through inappropriate use or be the cause of skin allergies. Prolonged and/or frequent use of waterproof gloves may be considered as a form of wet work, due to sweaty hands, frequent wet-dry cycles, and use of water or other chemical solutions that could run down the arms into the gloves as previously reported.[12,13] Various studies have shown that wet work is an independent risk factor for ICD.[12,13] Furthermore, constituent chemicals in addition to latex present in these gloves may be another contributory factor to WRSS or ACD.

The use of 10% formalin during specimen preparation was associated with PCU in this study. Furthermore, a dose–response relationship for PCU was evident between the specimen preparation activity and chemical agents involved. Although better known as a causative agent for ACD, formalin has also been reported to cause occupational contact urticaria.[30,31] Further evidence is necessary to better explore this association.

In this study, OPA was used for disinfection of instruments in the South African hospital, while GTA was used in the Tanzanian hospital. OPA was initially suggested as a safer alternative to GTA but is now known to cause both irritant and IgE-mediated allergic reactions, more so than GTA.[32] Furthermore, concomitant irritant and allergic reactions, including reports of occupational asthma and anaphylaxis, have previously been attributed to OPA.[33] However, neither OPA nor GTA were significantly associated with skin symptoms in this current study. Similarly, chlorhexidine was also not significantly associated with work-related skin problems in this study, although it has previously been reported as an occupational allergen.[10,11,34]

Other chemical factors significantly associated with WRSS identified in this study included a high personal domestic cleaning frequency, especially when using ammonia-based cleaners in unadjusted models. Personal involvement in domestic cleaning, particularly when using household bleach, has been reported as a risk factor for work-related respiratory symptoms.[22,35] The apparent protective associations found for WRSS and use of bleach for cleaning and disinfecting medical instruments in adjusted models, were however not observed for other bleach-related work tasks. Recently, Garrido et al.[36] reported a two-fold increased odds of work-related hand dermatitis associated with bleach use at work. It is possible that task-specific effect modifiers such as the concentration of bleach used, or specific PPE worn that varied between work activities may explain these discrepant findings. The biological mechanisms for these associations remain unclear and future studies need to explore this further.

Although training was not a protective factor in this study, other studies have found that it does play an important role. Rahman et al.[37] reported that knowledge of occupational hazards lowered the prevalence of OCD in chemical industry workers and Mekonnen et al.[9] found that a lack health and safety training in HWs was associated with an increased odds of OCD ($OR_{adj} = 2.12$, 95% CI: 1.12–2.25). More recently, Symanzik et al.[20] demonstrated the benefit of health education and skin care in preventing hand eczema in HWs during the COVID-19 pandemic. Training is generally easily implementable in the workplace as part of the occupational health and safety training programme and has the potential to reduce occupational risks if conducted in a sustained manner.

This is the first study to provide information on occupational factors associated with WRSS in the African setting. A strength of the study is that it obtained detailed information on the duration and frequency of various chemical and job task exposures, to assess dose–response relationships. Since this was a cross-sectional study, time-dependent data were not available to assess temporal associations. It is also probable that some of the 'protective associations' observed may have been due to a healthy worker effect. Another consideration is that the operational definitions for PCD, PCU, and WRSS were developed based on the presence of specific self-reported symptoms to increase the sensitivity of detecting possible associations. This could introduce diagnostic bias since the presence of symptoms does not necessarily imply disease. However, more than one definition was used for WRSS in the last 12 months to improve the specificity of this outcome and similar results were observed for both outcomes. Future studies should include more objective measures such as quantitative exposure assessments in the form of biomonitoring where appropriate, clinical examinations and suitable diagnostic investigations (e.g., patch testing). Furthermore, detailed information on glove usage practices could have provided better insights into their impact on

adverse skin outcomes. Finally, while this study did not explore the relationship between work-related skin and respiratory symptoms associated with cleaning agents, a recent systematic review reported that there was limited evidence for such a relationship and suggested further research in this regard.[38]

In conclusion, this study demonstrated an association between exposure to various cleaning agents in tertiary hospitals and WRSS reported by HWs. Significant associations were observed for exposures related to cleaning and disinfection of instruments or patients' skin and wounds as well as specimen preparation. The importance of preventive measures such as glove use when cleaning and disinfecting patients' skin or wounds has been highlighted. Further research into dose–response relationships using objective measures of exposure and adverse skin outcomes could provide more specificity to the associations observed. In addition, research on the underlying mechanisms for these associations could provide improved insights into the early detection of work-related skin disease in HWs.

AUTHOR CONTRIBUTIONS

Sonday Z: Writing – original draft. **Baatjies R:** Supervision. **Mwanga HH:** Resources. **Jeebhay MF:** Supervision.

CONFLICT OF INTEREST STATEMENT

There is no conflict of interest to declare.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Sonday Z, Baatjies R, Mwanga HH, Jeebhay MF. Prevalence of work-related skin symptoms and associated factors among tertiary hospital workers exposed to cleaning agents in Southern Africa. *Contact Dermatitis*. 2023;89(3):178-189. doi:10.1111/cod.14374