
Contact dermatitis to personal care products is increasing (but different!) in males and females: North American Contact Dermatitis Group data, 1996-2016



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Background: Personal care products (PCPs) are commonly responsible for allergic contact dermatitis and irritant contact dermatitis. PCP use was historically associated with females, but male-targeted PCPs are increasingly being marketed.

Objective: To characterize and compare males with PCP-related contact dermatitis (MPCPs) and females with PCP-related contact dermatitis (FPCPs).

Methods: This was a retrospective cross-sectional analysis of North American Contact Dermatitis Group data (1996-2016).

Results: Four thousand six hundred eighty of 16,233 men (28.8%) and 12,730 of 32,222 (39.5%) women had a PCP identified as a source of irritant contact dermatitis or a positive patch test reaction. The proportion of PCP-related dermatitis in both sexes significantly increased (>2.7-fold) over the decade of study. Compared with FPCPs, a larger proportion of MPCPs were older or had trunk or extremity dermatitis ($P < .0001$). MPCPs were twice as likely to have soaps as a source while FPCPs were twice as likely to have hair care products ($P < .0001$). The most common PCP-related North American Contact Dermatitis Group allergens for both sexes were methylisothiazolinone (MPCP 28.8% and FPCP 21.5%), fragrance mix I (MPCP

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22.3% and FPCP 20.1%), balsam of Peru (MPCP 18.5% and FPCP 14.1%), quaternium-15 (MPCP 16.1% and FPCP 12.3%), and paraphenylenediamine (MPCP 11.5% and FPCP 11.1%).

Limitations: Patient population referred for suspected contact dermatitis.

Conclusions: PCP-related dermatitis is increasing. Sites of involvement and relevant PCP sources are distinct between sexes. Male and female variation in exposure history may explain differences in reactivity to some allergen groups. (J Am Acad Dermatol 2021;85:1446-55.)

Key words: allergic contact dermatitis; irritant contact dermatitis; patch testing; personal care products; sex; soaps; methylisothiazolinone.

While women have historically been the major consumers of personal care products (PCPs), brands are increasingly marketing products specifically “for men.”¹ A 2004 study found that males used a daily average of 6 PCPs with 85 ingredients while females used 12 PCPs with 168 ingredients²; recent studies have found higher rates of PCP usage³⁻⁵ and highlight that specific product type use varies by sex.⁶

Both irritant contact dermatitis (ICD) and allergic contact dermatitis (ACD) may be associated with PCPs.⁷⁻¹⁰ A 2013 survey of 1531 European and 300 US-based dermatologists found that 82% and 58%, respectively, noted a 5-year increase in males reporting sensitive facial skin; most attributed this to the increased use of male cosmetics.¹¹

Previous North American Contact Dermatitis Group (NACDG) analyses have reported PCP-associated patch test reactions¹²⁻¹⁵ but detailed analysis by sex has been lacking.

METHODS

Database

The Minneapolis Veterans Affairs Medical Center's Human Studies Subcommittee approved this study. NACDG methodology is standardized.¹⁶

Study population

Several study groups were identified: 1) males with personal PCP source(s) associated with positive patch test allergen(s) or ICD (MPCPs); 2) all other males (AOMs); 3) females with personal PCP source(s) associated with positive allergen(s) or ICD (FPCPs); and 4) all other females (AOFs). Individuals with missing values for sex or source were excluded (n = 17).

CAPSULE SUMMARY

- Personal care products (PCPs) are often relevant sources of contact dermatitis.
- PCP-related contact dermatitis is increasing but is distinct based on sex. This study provides insight into the emerging role of PCPs in males and enables dermatologists to better understand nuances of PCP-related dermatitis in men and women.

PCP variables

The NACDG used 2 source coding systems during the study. From 1996 to 2000, a limited list of 9 source codes were used; PCP sources were defined as “cosmetics/beauty preparations, skin and health care products.” From 2001 to 2016, >200 source codes were used. PCPs were defined according to US Food and Drug Administration guidelines for “cosmetics” which specifically excludes sun-

screens and eye care products.¹⁷

Clinically relevant reactions with a final interpretation code of “allergic/positive” (regardless of reaction strength) and associated with PCP sources were included; clinical relevance included current (definite, probable, or possible) or past relevance. Before 2001, sources of ICD or non-NACDG positive relevant allergens were not recorded.

Data management and statistical analysis

Data were entered in Access and Excel (Microsoft Corp, Redmond, WA). Frequencies were presented with counts and proportions. Chi square and *t* tests were used to examine associations with categorical and continuous variables, respectively. Cochran–Armitage trend tests were used for change over time (SAS 9.2; SAS Inc, Cary, NC).

RESULTS

Frequency of PCP-related dermatitis

Forty eight thousand four hundred seventy-two patients were patch tested, including 16,233 men and 32,222 women. Overall, MPCPs represented 28.8% of males and FPCPs represented 39.5% of females. The proportion of PCP-related dermatitis significantly increased from 1996 to 1998 (MPCPs 16.9%, FPCPs 21.9%) to 2015 to 2016 (MPCPs 35.1%, FPCPs 49.4%; odds ratio [95% confidence interval {CI}] for males

Abbreviations used:

ACD:	allergic contact dermatitis
AOF:	all other females
AOM:	all other males
FPCP:	female with personal care product -related dermatitis
ICD:	irritant contact dermatitis
MCI:	methylchlorisothiazolinone
MI:	methylisothiazolinone
MPCP:	male with personal care product -related dermatitis
NACDG:	North American Contact Dermatitis Group
PCP:	personal care product
PPD:	paraphenylenediamine

2.68 [2.26-3.18], $P < .0001$; odds ratio [95% CI] for females 3.48 [3.11-3.89], $P < .0001$; [Fig 1](#)). The number of PCP-related positive allergic reactions (both NACDG and non-NACDG allergens) was 9106 for MPCPs (1.95 reactions/male) and 21,277 for FPCPs (1.67 reactions/female, $P < .0001$).

Demographics

MPCP vs FPCP. In pairwise comparisons, MPCPs were significantly older (52.3 vs 48.6 years, $P < .0001$) and less likely to have a history of any atopic condition than FPCPs (relative risk [RR] 0.87 [95% CI 0.84-0.91]). MPCPs were also more likely to have extremity (hand RR 1.30 [95% CI 1.23-1.38], arm RR 1.52 [95% CI 1.40-1.64], leg RR 1.64 [95% CI 1.49-1.80], and foot RR 2.56 [95% CI 2.23-2.93]) and trunk dermatitis (RR 1.39 [95% CI 1.28-1.52]) but were less likely to have scalp, ear, or neck (RR 0.46 [95% CI 0.42-0.50]) or facial involvement (RR 0.36 [95% CI 0.34-0.39], P values $< .0001$; [Table I](#)).

MPCPs vs AOMs. Compared with AOMs, MPCPs were older (52.3 vs 47.9 years, $P < .0001$), more likely to have a scattered generalized pattern of dermatitis (RR 1.28 [95% CI 1.21-1.35]) or scalp, ear, or neck involvement (RR 1.42 [95% CI 1.28-1.59]) but were less likely to have hand/foot dermatitis (hand RR 0.85 [95% CI 0.81-0.90]; foot RR 0.63 [95% CI 0.56-0.70], P values $< .0001$; [Table I](#)).

FPCP vs AOFs. Compared with AOFs, FPCPs were older (48.6 vs 46.8 years, $P < .0001$) and were more likely to have facial (RR 1.22 [95% CI 1.19-1.25]) and scalp, ear, or neck dermatitis (RR 1.43 [95% CI 1.36-1.50]) but were less likely to have other involved body sites (hand RR 0.96 [95% CI 0.92-1.00], trunk RR 0.85 [95% CI 0.80-0.91], arm RR 0.81 [95% CI 0.76-0.86], leg RR 0.73 [95% CI 0.69-0.79], anal/genital RR 0.66 [95% CI 0.56-0.76], and foot RR 0.52 [95% CI 0.47-0.58], P values $< .0296$; [Table I](#)).

PCP sources

Currently relevant sources were analyzed in several groups: 1) NACDG allergens, 2) non-NACDG allergens, and 3) ICD ([Table II](#)). Compared with MPCPs, FPCPs were approximately twice as likely to have a hair care product-associated allergen (NACDG RR 1.64 [95% CI 1.52-1.75]; non-NACDG RR 2.04 [95% CI 1.61-2.56], P values $< .0001$) and approximately 1.5 times as likely to have a cosmetic-associated non-NACDG allergen or ICD (non-NACDG RR 1.39 [95% CI 1.22-1.56]; ICD RR 1.61 [95% CI 1.18-2.17], P values $< .0031$). MPCPs were approximately twice as likely to have soap-associated allergens/ICD than FPCPs (NACDG RR 1.85 [95% CI 1.66-2.06]; non-NACDG RR 2.17 [95% CI 1.60-2.95]; ICD RR 2.04 [95% CI 1.79-2.35], P values $< .0001$).

Clinically relevant PCP-related NACDG allergens

The top 5 most common PCP-related NACDG allergens for both sexes were the same: methylisothiazolinone (MI; MPCPs 28.8%, FPCPs 21.5%), fragrance mix I (MPCPs 22.3%, FPCPs 20.1%), balsam of Peru (MPCPs 18.5%, FPCPs 14.1%), quaternium-15 (MPCPs 16.1%, FPCPs 12.3%), and paraphenylenediamine (PPD; MPCPs 11.5%, FPCPs 11.1%). There was variation in likelihood of males versus females to have reactions to specific allergens ([Table III](#)). Allergen frequency in common sources is summarized in [Table IV](#).

DISCUSSION

PCP-related dermatitis has significantly increased in males and females referred for patch testing over the past 2 decades. While PCP-related dermatitis is more common in females, males who had PCP-related allergic reactions had a higher number of relevant allergens than females (2.0/male vs 1.7/female). Many sources of PCP-related allergens were similar in both sexes. However, males were proportionately twice as likely to have dermatitis related to soaps and females were twice as likely to have dermatitis related to hair products. The increased prevalence of hand dermatitis, older age, and specific allergen rates in males suggest a potential role of historical industrial exposure that may explain the increased frequency of dermatitis associated with PCPs among males.

Epidemiology

The previous prevalence of allergy to PCPs has been estimated to be $<1\%$ in the general population¹⁸⁻²⁰ and 9.8% in patch-tested patients.²¹ A Danish study found that contact sensitization to

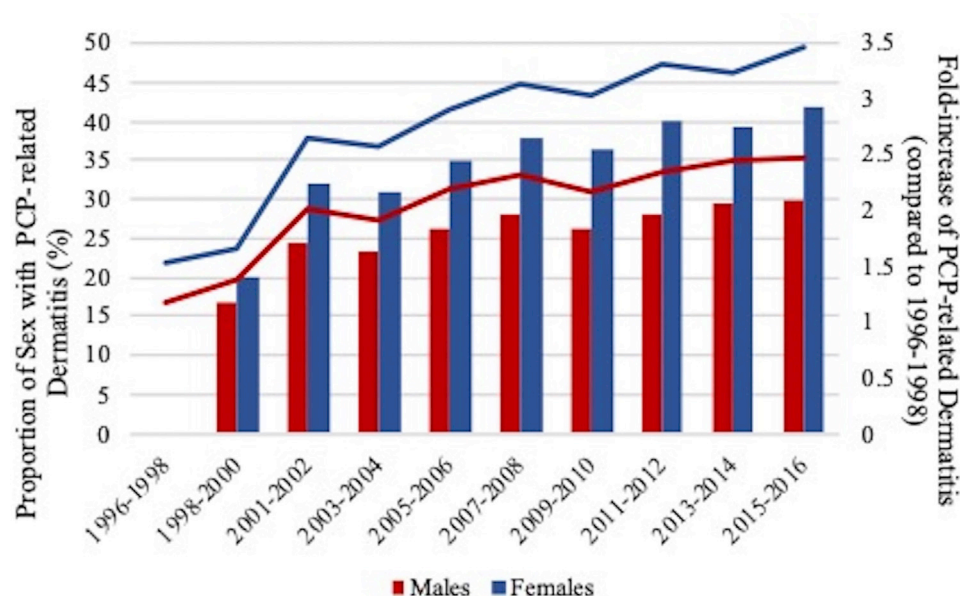


Fig 1. Proportion of male and female patients referred for patch testing with personal care product (PCP)-related contact dermatitis over 2-year North American Contact Dermatitis Group testing cycles. Bars demonstrate percentage (%) of each sex referred for patch testing with PCP-related dermatitis. Lines show the fold increase of these cases compared with males and females in the 1996 to 1998 testing cycle.

cosmetic allergens doubled from 1990 to 1998.¹⁹ Similarly, the current study found the frequency of PCPs as a source associated with positive patch test reactions or ICD more than doubled over the last 2 decades. This increased frequency may be related to the increased use of products,^{1,3-5,22-24} the inclusion of more allergenic ingredients, or the enhanced availability of patch testing.²⁰

Specific PCPs

MPCPs and FPCPs most commonly had positive reactions associated with moisturizers and shampoos and conditioners; females were twice as likely to have a positive reaction to an allergen in a hair care product, presumably because of the higher number of hair dyes, hair sprays, and perms used by women. MPCPs were twice as likely to have soaps associated with a positive reaction to an allergen and ICD. We speculate that males may encounter harsher soaps in occupational industrial settings,²⁵ use stronger soaps in general (eg, antibacterial soaps), or suggest that soap is overrepresented in the smaller range of products used by men compared with those used by women. While females use more PCPs than males, 1 study found that males who use certain products, including shampoos and conditioners or body cleansers, use these products more frequently²³ or in higher amounts.⁴ Increased exposure may increase the likelihood of both

irritation and sensitization from these products. This also may explain our study observation of a statistically higher number of allergic reactions per male compared with that per female. The increased sensitivity of males to soaps is consistent with their increased occurrence of hand and body dermatitis compared with the predominantly head and neck dermatitis observed in females, who reacted to more hair and facial products.

Relevant PCP-related allergens

The 5 most common allergens were the same in both MPCPs and FPCPs. However, allergens varied in each type of PCP. In cases such as propolis (often in lip products), it is expected that females encounter these allergens more frequently. However, there is no obvious explanation for whether or why gendered products carry specific allergens. A 2019 analysis of men's facial moisturizers suggests that newer products may contain fewer allergenic preservatives than their predecessors.²⁶

Methylisothiazolinone (MI) and methylchloroisothiazolinone (MCI). It is unsurprising that MI was the most frequent PCP-related allergen in both sexes; MI is one of the most common allergens worldwide¹⁶ and is used as a preservative in many PCPs. Leave-on products are one of the most common sources of sensitization to MI.²⁷ Importantly, many industrial products (eg, paints, glues,

Table I. Patient demographics of males and females with PCP-related dermatitis compared with all other tested patients, 1996 to 2016

Demographics	Males		Females		MPCPs vs FPCPs	
	PCP-related dermatitis (MPCPs), [*] N = 4680	PCP nonrelated dermatitis (AOMs), [†] N = 11,553	PCP-related dermatitis (FPCPs), [‡] N = 12,730	PCP-nonrelated dermatitis (AOFs), [§] N = 19,492	RR (95% CI)	P value
Age, years, n (%)						
<18	190 (4.1)	641 (5.5)	405 (3.2)	951 (4.9)	1.28 (1.08-1.54)	.0047
19-39	857 (18.3)	3093 (26.8)	3300 (25.9)	5620 (28.9)	0.71 (0.66-0.76)	<.0001
≥40 [#]	3564 (76.2) [¶]	7605 (65.8)	8771 (68.9) [¶]	12498 (64.2)	1.11 (1.08-1.13)	<.0001
White, n (%)	4111 (88.8) [¶]	10,077 (87.5)	10,963 (86.8) [¶]	16,462 (84.7)	1.02 (1.01-1.04)	.0006
Atopy history, [#] n (%)	2024 (43.5)	4980 (43.2)	6305 (49.8)	9508 (48.9)	0.87 (0.84-0.91)	<.0001
Anatomic site, ^{**} n (%)						
Generalized	1545 (21.1) [¶]	2927 (16.6)	2525 (12.1)	3452 (11.7)	1.75 (1.66-1.86)	<.0001
Hand [#]	1458 (19.9)	4148 (23.5)	3213 (15.3)	4731 (16.1)	1.30 (1.23-1.38)	<.0001
Face ^{††}	874 (12.0)	2110 (11.9)	6902 (32.9) [¶]	7955 (27.0)	0.36 (0.34-0.39)	<.0001
Arm [#]	847 (11.6)	2177 (12.3)	1603 (7.7)	2785 (9.5)	1.52 (1.40-1.64)	<.0001
Trunk	666 (9.1)	1491 (8.4)	1370 (6.5)	2259 (7.7)	1.39 (1.28-1.52)	<.0001
Leg [#]	609 (8.3)	1467 (8.3)	1065 (5.1)	2045 (6.9)	1.64 (1.49-1.80)	<.0001
Scalp, ear, or neck	484 (6.6) [¶]	822 (4.7)	3042 (14.5) [¶]	2992 (10.2)	0.46 (0.42-0.50)	<.0001
Foot [#]	374 (5.1)	1440 (8.1)	419 (2.0)	1127 (3.8)	2.56 (2.23-2.93)	<.0001
Anal/genital	177 (2.4)	387 (2.2)	248 (1.2)	532 (1.8)	2.05 (1.69-2.48)	<.0001
Occupational skin condition, ^{#,‡‡} n (%)	720 (15.4)	2582 (22.4)	1238 (9.8)	1983 (10.2)	1.58 (1.45-1.72)	<.0001

AOFs, All other females; AOMs, all other males; CI, confidence interval; FPCPs, females with PCP-related contact dermatitis; MPCPs, males with PCP-related contact dermatitis; NOS, not otherwise specified; PCP, personal care product; RR, relative risk.

*Age missing for 1 patient, race missing for 49 patients, allergic rhinitis history missing for 14 patients, eczema history missing for 26 patients, asthma history missing for 14 patients, site missing for 2 patients, and occupational-relatedness missing for 8 patients.

[†]Age missing for 3 patients, race missing for 39 patients, allergic rhinitis history missing for 18 patients, eczema history missing for 22 patients, asthma history missing for 21 patients, site missing for 9 patients, and occupational-relatedness missing for 14 patients.

[‡]Age missing for 3 patients, race missing for 101 patients, allergic rhinitis history missing for 44 patients, eczema history missing for 72 patients, asthma history missing for 38 patients, site missing for 7 patients, and occupational-relatedness missing for 33 patients.

[§]Age missing for 13 patients, race missing for 64 patients, allergic rhinitis history missing for 34 patients, eczema history missing for 38 patients, asthma history missing for 34 patients, site missing for 20 patients, and occupational-relatedness missing for 22 patients.

^{||}Indicates statistically significant result ($P < .05$) that this demographic finding occurred less often in MPCPs and FPCPs compared with AOMs and AOFs, respectively.

[¶]Indicates statistically significant result ($P < .05$) that this demographic finding occurred more often MPCPs and FPCPs compared with AOMs and AOFs, respectively.

[#]MOHALFA index (male, occupational-relatedness, hand/arm/leg/foot involvement, and atopic history).

^{**}Total number of affected sites (≤ 3 sites per patient).

^{††}Facial involvement includes face NOS, eyes, eyelids, lips, and nose.

^{‡‡}Overall skin condition related to occupation.

Table II. Personal care product sources of NACDG screening allergens, non-NACDG allergens, and irritants in MPCPs and FPCPs, 2001 to 2016

PCP type, n (%)	NACDG screening allergens associated with PCP source		Non-NACDG allergen associated with PCP source*		Irritant contact dermatitis associated with PCP source*	
	Reactions [†] in MPCPs, N = 7589	Reactions [†] in FPCPs, N = 18,461	MPCPs, N = 716	FPCPs, N = 2926	MPCPs, N = 235	FPCPs, N = 1649
Cosmetics	2057 (27.1)	5193 (28.1)	204 (28.5) [‡]	1152 (39.4)	36 (15.3) [‡]	405 (24.6)
Moisturizers/lotions/creams	1365 (18.0)	2759 (14.9)	106 (14.8)	467 (16.0)	9 (3.8)	164 (9.9)
Perfumes/fragrances	178 (2.3)	530 (2.9)	35 (4.9)	163 (5.6)	6 (2.6)	15 (0.9)
Deodorants/antiperspirants	106 (1.4)	57 (0.3)	23 (3.2)	23 (0.8)	16 (6.8)	28 (1.7)
Lipsticks/lip balms	15 (0.2)	200 (1.1)	9 (1.3)	155 (5.3)	1 (0.4)	25 (1.5)
Make-up	4 (0.1)	380 (2.1)	1 (0.1)	180 (6.2)	1 (0.4)	95 (5.8)
Cosmetics NOS	389 (5.1)	1267 (6.9)	30 (4.2)	164 (5.6)	3 (1.3)	78 (4.7)
Hair care products	834 (11.0) [‡]	3321 (18.0)	69 (9.6) [‡]	575 (19.7)	33 (14.0)	246 (14.9)
Shampoos/conditioners	490 (6.5)	1474 (8.0)	14 (2.0)	128 (4.4)	19 (8.1)	107 (6.5)
Hair dyes	259 (3.4)	1289 (7.0)	43 (6.0)	326 (11.1)	1 (0.4)	54 (3.3)
Hair styling products	29 (0.4)	86 (0.5)	4 (0.6)	16 (0.5)	3 (1.3)	1 (0.1)
Permanent wave products	15 (0.2)	169 (0.9)	2 (0.3)	24 (0.8)	0	4 (0.2)
Hair care products NOS	41 (0.5)	303 (1.6)	6 (0.8)	81 (4.1)	10 (4.3)	80 (4.9)
Soaps [§]	526 (7.0)	692 (3.7)	59 (8.3)	111 (3.7)	133 (56.7)	456 (27.6)
Wipes	39 (0.5)	112 (0.6)	7 (1.0)	8 (0.3)	2 (0.9)	4 (0.2)
Nail care products	28 (0.4) [‡]	980 (5.3)	1 (0.1) [‡]	128 (4.4)	0	22 (1.3)
PCPs NOS	4105 (54.1)	8163 (44.2)	376 (52.5)	952 (32.5)	31 (13.2)	516 (31.3)

FPCPs, Females with PCP-related contact dermatitis; MPCPs, males with PCP-related contact dermatitis; NACDG, North American Contact Dermatitis Group; NOS, not otherwise specified; PCP, personal care product.

*Only 1 non-NACDG allergen source and only 1 irritant contact dermatitis source could be coded per patient.

[†]Patients could have multiple NACDG allergens associated with a PCP source.

[‡]Source was statistically significantly ($P < .05$) less often identified in MPCPs compared with FPCPs.

[§]Includes only products for skin use (excludes household cleansers, such as dish soap, laundry soap, and surface cleaners).

^{||}Source was statistically significantly ($P < .05$) more often identified in MPCPs compared with FPCPs.

pesticides, oils, and gasolines) and industrial “heavy-duty” hand cleansers contain isothiazolinones. The ubiquitous nature of MI/MCI in both industrial settings and PCPs may reflect 2 distinct pathways of sensitization and exposures, particularly among males.

Fragrance. Approximately 1% of the general population is estimated to be patch test–positive to fragrance allergens.²⁸ Fragrances are the most common allergens found in PCPs.^{26,29,30} While fragrance ingredients are used in most male and female products, specific fragrances vary in products for each sex³¹ and may explain some differences in exposure and reactivity.

Formaldehyde releasers. Although reactions to formaldehyde and formaldehyde releasers were common in both sexes, frequency was generally higher in males. Formaldehyde releasers have been historically used to preserve PCPs but have become less common as concerns about formaldehyde safety have grown.³²⁻³⁴ As of 2017, formaldehyde releasers are found in only 10% of PCPs in the Contact Allergen Management Program.³⁵ Importantly, studies have documented the release

of formaldehyde from PCPs that do not declare this.³⁶⁻³⁹ A 2018 NACDG analysis of 891 patients with allergic contact dermatitis associated with skin cleansers identified quarternium-15 as the most common allergen in 11.2% of patch-tested individuals; 22.0% of these reactions were occupationally related exposures.⁴⁰ It is possible that some males may have been sensitized to formaldehyde chemicals in industrial settings (eg, quarternium-15 in industrial hand cleansers; formaldehyde in construction, manufacturing, or mechanical work) and subsequently react to PCPs containing these preservatives or perhaps that there may be historically higher use of formaldehyde-releasing preservatives in products marketed for men⁴¹; the frequency of men in such industrial settings is higher than that of women.⁴² Consistent with our results, a 2020 analysis found that provider Contact Allergen Management Program searches for formaldehyde/quarternium-15/bronopol were at least 5 positions higher in allergenicity rank order for males than females.⁴³

Surfactants. MPCPs were significantly more likely to react to cocamidopropyl betaine and

Table III. Top 30 clinically relevant NACDG allergens associated with PCPs in MPCPs and FPCPs based on the percentage of tested patients

Rank			MPCPs		FPCPs	
MPCPs	FPCPs	NACDG allergen	Percent of patients (n/N)	Percent of reactions, N = 9106	Percent of patients (n/N)	Percent of reactions, N = 21,277
1	1	MI, 0.01% aq/pet*	28.8 (307/1067)	3.4	21.5 (764/3559)	3.6
2	2	Fragrance mix I, 8% pet	22.3 (1041/4676)	11.4	20.1 (2556/12722)	12.0
3	3	Balsam of Peru, 25% pet	18.5 (864/4679)	9.5 [†]	14.1 (1793/12724)	8.4
4	4	Quaternium-15, 2% pet	16.1 (753/4673)	8.3 [†]	12.3 (1560/12712)	7.3
5	5	Paraphenylenediamine, 1% pet	11.5 (538/4670)	5.9 [‡]	11.1 (1405/12694)	6.6
6	9	Methyldibromoglutaronitrile/phenoxyethanol, 2/2.5% pet	11.1 (517/4674)	5.7 [†]	5.6 (713/12724)	3.4
7	7	Formaldehyde, 1% and 2% aq	10.4 (488/4675)	5.4	9.0 (1149/12717)	5.4
8	6	Fragrance mix II, 14% pet	9.3 (236/2528)	2.6 [‡]	9.1 (693/7647)	3.3
9	13	Diazolidinyl urea (Germall 115), 1% aq/pet	8.6 (402/4676)	4.4 [†]	4.6 (588/12726)	2.8
10	8	MCI/MI, 0.01% aq/pet	8.6 (402/4676)	4.4	7.7 (982/12715)	4.6
11	19	Imidazolidinyl urea, 2% aq/pet	7.4 (347/4675)	3.8 [†]	3.8 (483/12727)	2.3
12	14	Cinnamic aldehyde, 1% pet	6.8 (286/4199)	3.1 [†]	4.5 (516/11494)	2.4
13	10	Lanolin alcohol, 30/50% pet	6.3 (297/4678)	3.3	5.2 (658/12724)	3.1
14	12	Methyldibromoglutaronitrile, 0.4% pet	6.3 (55/880)	0.6	4.9 (104/2123)	0.5
15	21	Propylene glycol, 30% and 100% aq	6.2 (288/4676)	2.7 [†]	3.5 (447/12727)	2.1
16	26	Cocamidopropyl betaine, 1% aq	6.1 (245/4012)	2.7 [†]	2.8 (317/11266)	1.5
17	16	DMDM hydantoin, 1% aq/pet	5.9 (278/4674)	3.1 [†]	3.9 (502/12726)	2.4
18	17	Iodopropynyl butylcarbamate, 0.5% pet	5.5 (243/4417)	3.2 [†]	3.9 (473/12158)	2.2
19	11	Oleamidopropyl dimethylamine, 0.1% aq	5.3 (102/1928)	1.1 [‡]	5.1 (317/6182)	1.5
20	25	Amidoamine (stearamidopropyl dimethylamine), 0.1% aq	4.5 (197/4417)	2.2 [†]	2.9 (352/12161)	1.7
21	20	Dimethylaminopropylamine, 1% aq	4.1 (79/1930)	0.9 [‡]	3.8 (232/6180)	1.1
22	24	2-bromo-2-nitropropane 1,3-diol, 0.5% pet	3.9 (180/4675)	2.0	3.0 (376/12725)	1.8
23	28	Decyl glucoside, 5% pet	3.2 (61/1929)	0.7	2.4 (148/6181)	0.7
24	38	Paraben mix, 12% pet	2.7 (127/4676)	1.4 [†]	1.3 (171/12728)	0.8
25	35	Cocamide diethanolamine, 0.5% pet	2.4 (98/4012)	1.1	1.7 (192/11268)	0.9
26	34	Ylang ylang, 2% pet	2.1 (84/4010)	0.9	1.7 (193/11268)	0.9
27	20	Propolis, 10% pet	1.5 (39/2524)	0.4 [‡]	3.1 (237/7649)	1.1
28	33	Tea tree oil, 5% pet	1.5 (52/3536)	0.6 [‡]	1.7 (172/10039)	0.8
29	36	Tocopherol, 100%	1.3 (57/4481)	0.6	1.4 (170/12495)	0.8
30	37	Jasmine, 2% pet	1.2 (34/2859)	0.4	1.4 (106/7812)	0.5

Aq, Aqueous; FPCPs, females with PCP-related contact dermatitis; MCI, methylchloroisothiazolinone; MI, methylisothiazolinone; MPCPs, males with PCP-related contact dermatitis; NACDG, North American Contact Dermatitis Group; PCP, personal care product; pet, petrolatum.

*Only tested for 2 cycles.

[†]Indicates that allergen was statistically significantly ($P < .05$) more often identified in MPCPs compared with FPCPs.

[‡]Indicates that allergen was statistically significantly ($P < .05$) less often identified in MPCPs compared with FPCPs.

Table IV. Most common clinically relevant NACDG screening allergens associated with specific PCPS in MPCPs and FPCPs, 2001 to 2016

Among MPCPs			Among FPCPs	
Rank	Moisturizers/creams/lotions	n (%), N = 1365	Moisturizers/creams/lotions	n (%), N = 2759
1	Quaternium-15	201 (14.7)	Quaternium-15	366 (13.3)
2	Diazolidinyl urea	114 (8.3)	Fragrance mix I	360 (13.0)
3	Methyldibromoglutaronitrile/ phenoxyethanol	110 (8.1)	Formaldehyde	206 (7.5)
4	Formaldehyde	106 (7.8)	Lanolin alcohol	194 (7.0)
5	Fragrance mix I	103 (7.5)	Methyldibromoglutaronitrile/ phenoxyethanol	157 (5.7)
6	Lanolin alcohol	96 (7.0)	MCI/MI	148 (5.4)
7	Imidazolidinyl urea	94 (6.9)	Diazolidinyl urea	142 (5.1)
8	DMDM hydantoin	76 (5.6)	Balsam of Peru	126 (4.6)
9	Propylene glycol	69 (5.0)	DMDM hydantoin	117 (4.2)
10	Balsam of Peru	68 (5.0)	Fragrance mix II	108 (3.9)
Soaps		n (%), N = 526	Soaps	n (%), N = 692
1	Quaternium-15	49 (12.5)	MCI/MI	56 (8.9)
2	Cocamidopropyl betaine	48 (12.2)	Cocamide diethanolamine	55 (8.8)
3	MCI/MI	43 (11.0)	MI	53 (8.5)
4	Fragrance mix I	41 (10.5)	Quaternium-15	51 (8.1)
5	Balsam of Peru	29 (7.4)	Fragrance mix I	47 (7.5)
6	Amidoamine	22 (5.6)	Cocamidopropyl betaine	43 (6.9)
7	Cocamide diethanolamine	19 (4.8)	Chloroxylenol	40 (6.4)
8	Formaldehyde	17 (4.3)	Formaldehyde	37 (5.9)
9	Chloroxylenol	16 (4.1)	Amidoamine	31 (4.9)
10	Dimethylaminopropylamine	14 (3.6)	Decyl glucoside	29 (4.6)
Shampoos/conditioners		n (%), N = 490	Shampoos/conditioners	n (%), N = 1474
1	MI	102 (20.8)	MI	268 (18.2)
2	MCI/MI	82 (16.7)	MCI/MI	238 (16.1)
3	Cocamidopropyl betaine	78 (15.9)	Cocamidopropyl betaine	142 (9.6)
4	Amidoamine	52 (10.6)	Dimethylaminopropylamine	130 (8.8)
5	Dimethylaminopropylamine	33 (6.7)	Amidoamine	125 (8.5)
6	Quaternium-15	19 (3.9)	Oleamidopropyl dimethylamine	103 (7.0)
7	Fragrance mix I	18 (3.7)	Fragrance mix I	84 (5.7)
8	Oleamidopropyl dimethylamine	18 (3.7)	Cocamide diethanolamine	56 (3.8)
9	Cocamide diethanolamine	14 (2.9)	Quaternium-15	48 (3.3)
10	DMDM hydantoin	13 (2.6)	DMDM hydantoin	40 (2.7)

FPCPs, Females with PCP-related contact dermatitis; MCI, methylchloroisothiazolinone; MI, methylisothiazolinone; MPCPs, males with PCP-related contact dermatitis; NACDG, North American Contact Dermatitis Group; PCP, personal care product.

amidoamine while FPCPs were more likely to react to oleamidopropyl dimethylamine and dimethylaminopropylamine. These surfactants are chemically related.^{44,45} In the aforementioned NACDG analysis of reactions to soaps/cleansers, positive reactions to cocamidopropyl betaine (9.5%) and amidoamine (5.5%) were more commonly associated with these products than oleamidopropyl dimethylamine (2.8%) and dimethylaminopropylamine (1.8%).⁴⁰ More frequent handwashing in males with harsher ingredients, such as during occupational industrial work,²⁵ could explain a greater sensitization to cocamidopropyl betaine and amidoamine in males.

Paraphenylenediamine (PPD). PPD, commonly found in hair dye, was the fifth most common allergen in both males and females. Recent estimates suggest that 70% of women⁴⁶ and 11%⁴⁷ to 46%⁴⁸ of men use hair-coloring products. Importantly, facial hair may be dyed among men and represent a unique method of exposure/sensitization. In addition, males can encounter PPD ubiquitously through both leisure (eg, wetsuits, auto equipment, and exercise equipment) and work exposure to compounds that contain PPD or its cross-reactor black rubber (eg, tires, gloves, work boots, or wire insulation). Some of these exposures have historically been more common among males than females and may cause

disproportionate sensitization of males to PPD, which later results in ACD when PPD-containing hair dye is used.

Limitations

The study population represents individuals referred to tertiary centers and therefore may not be generalizable. In the NACDG database, only 1 source may be coded for each positive allergen. This may result in using less specific coding. Gender identity was not assessed.

In conclusion, PCPs are major sources associated with both positive patch test reactions and ICD. Usage has grown in women and especially in men. This likely explains the increased frequency of ACD and ICD caused by these products in both sexes over the past 2 decades. Variation in exposure history to allergens and types of PCPs may explain differences in allergen frequency.

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