

Importance of Supplemental Patch Testing Beyond a Screening Series for Patients With Dermatitis

The North American Contact Dermatitis Group Experience

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IMPORTANCE Patch test screening series for patients with dermatitis are limited and may miss clinically relevant contact allergens.

OBJECTIVE To characterize individuals with dermatitis who showed clinically relevant patch test findings to supplemental (nonscreening) allergens or substances.

DESIGN, SETTING, AND PARTICIPANTS A 17-year, retrospective cross-sectional analysis (January 1, 2001, to December 31, 2018) of North American Contact Dermatitis Group (NACDG) data from multiple centers in North America was conducted. A total of 43 417 patients with dermatitis underwent patch testing to the NACDG screening series in a standardized manner with 65 to 70 allergens and supplemental allergens as clinically indicated. Patients with 1 or more clinically relevant reactions to a supplemental (nonscreening) allergen/substance were analyzed between November 18, 2020, and March 12, 2021.

MAIN OUTCOMES AND MEASURES The main outcomes were to assess the number of patients with clinically relevant reactions to supplemental (nonscreening) allergens and compare characteristics (including demographic characteristics and occupations) between patients with a clinically relevant patch test reaction to 1 or more supplemental allergens or substances (supplement-positive) and those without a reaction (supplement-negative) using odds ratios (ORs) and 95% CIs. Secondary outcomes included sources of allergic contact dermatitis and, for occupationally related cases, specific occupations and industries.

RESULTS Of 43 417 patients included in the study who underwent patch testing to the NACDG screening series (65-70 allergens), 9507 individuals (21.9%) had currently relevant reactions to 1 or more supplemental allergens or substances. Of these, 6608 were women (69.5%) and the mean (SD) age was 47.2 (0.54) years. Compared with patients who had supplement-negative results, patients with supplement-positive findings were significantly less likely to be male (OR, 0.90; 95% CI, 0.85-0.94; $P < .001$) and/or have atopic dermatitis (OR, 0.89; 95% CI, 0.84-0.93; $P < .001$). Common primary sites of dermatitis in 9499 patients with supplement-positive findings included the face (2856 [30.1%]), hands (2029 [21.4%]), and scattered/generalized distribution (1645 [17.3%]). Frequent sources of supplemental allergens in 9235 patients included personal care products (4746 [51.4%]) and clothing/wearing apparel (1674 [18.1%]). Of 9362 patients with available data, supplemental allergens/substances were occupationally related in 1580 (16.9%); of those with identified occupations, 25.1% (384 of 1529) were precision production, craft, or repair workers. Of 9507 patients with supplement-positive findings, 2447 (25.7%) had no currently relevant reactions to NACDG screening allergens.

CONCLUSIONS AND RELEVANCE This cross-sectional study found that 21.9% of patients who underwent patch testing to an allergen screening series of 65 to 70 allergens had at least 1 relevant reaction to supplemental allergens/substances. Of these, one-quarter reacted only to a supplemental allergen/substance. Screening series include common, important allergens, but these findings suggest that the addition of specialty allergens and personal or work products is critical for the successful diagnosis and management of allergic contact dermatitis.

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Epicutaneous patch testing is an important tool for investigating allergic contact dermatitis (ACD).¹ Screening series generally include common sensitizers and are not meant to be comprehensive. Additional specialty allergens (eg, cosmetics, textiles, dental, and adhesives) are typically applied at the same time as the screening series based on patient history, physical examination, and/or environmental/occupational exposure. In addition, personal products and work materials may be tested.

Most countries or regions have a recommended screening series (also referred to as baseline, standard, or core series). For example, the Korean Standard Screening Series contains 25 allergens² and the American Contact Dermatitis Society Core Allergen Series contains 90 allergens.³ In general, identification of allergens by a screening series is related to the number of allergens in that series. Patel and Belsito⁴ found that only 28.5% of patients with clinically relevant reactions had all reactions identified with a 28-allergen screening series, compared with 45.1% of patients with a 65-allergen screening series. Watts and colleagues⁵ found that adding 4 allergens to the British Standard Series (41 allergens) detected an additional 15.6% of contact allergy.

As summarized in **Table 1**, previous studies reported that screening series of 30 or fewer allergens identify all allergens in approximately 23% to 55% of patients tested; in other words, 45% to 77% of patients would have had at least 1 allergen missed if testing was limited to a screening series of 30 allergens or less.^{4,6-10} Although larger screening series (>30 allergens) identify all allergens in more patients, 13% to 72% of patients would still have at least 1 allergen missed.^{4,5,11-14} Most studies report only percentages of positive allergens (regardless of clinical relevance); proportions of clinically relevant allergens would be lower. Because relevance is assessed at the time of the final reading, most studies are also limited by lack of long-term follow-up.

Although proportions of patients with clinically relevant reactions to supplemental allergens/substances are reported periodically by the North American Contact Dermatitis Group (NACDG) and others,^{4,15-23} detailed data are lacking. Herein, we describe specific factors of this population as well as sources of supplemental allergens and their association with occupation.

Methods

NACDG Database

Between January 1, 2001, and December 31, 2018, the NACDG screening series consisted of 65 to 70 allergens, changing slightly in composition every 2 years (Chemotechnique Diagnostics AB and allergEAZE SmartPractice).¹⁵⁻²³ Additional supplemental patch tests were chosen based on clinical and occupational history. Supplemental allergens could include commercially available specialty series (>500 different commercial allergens are available from Chemotechnique Diagnostics AB or allergEAZE SmartPractice, which can be purchased in sets and series or as individual allergens) as well as personal and work substances (eg, per-

Key Points

Question Do some patients with dermatitis have clinically relevant patch test reactions to supplemental allergens/materials not detected by a screening series of 65 to 70 allergens?

Findings In this cross-sectional study including 43 417 patients with dermatitis, 22% had a currently relevant reaction to 1 or more supplemental allergens or substances. Of these patients, 26% had no currently relevant reactions to 65 to 70 screening allergens.

Meaning These findings suggest that comprehensive patch testing with more than 70 allergens, including supplemental series and personal and work materials, is necessary for proper identification of allergens and successful management of allergic contact dermatitis.

sonal care products [PCPs], hobby and work materials, glues, gloves, and shoes).

This cross-sectional analysis of deidentified data was approved by the Minneapolis Veterans Affairs Medical Center Subcommittee on Human Studies, waiving patient informed consent. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.

Patient data included demographic characteristics (age, sex, occupation), history of atopy (asthma, hay fever, atopic dermatitis), and anatomic sites of dermatitis (≤ 3 sites). Methods of patch testing, grading of reactions, and recording of data were performed according to the NACDG protocol.^{18,22} Briefly, readings were performed at 48 hours and 72 to 168 hours after application. In addition to grading reactions to allergens on the NACDG screening series, the presence of at least 1 currently relevant supplemental allergen/substance was recorded (yes or no, with name of allergens not recorded); the source of that supplemental allergen/substance and its association with occupation were also recorded. Occupation was coded by a classification expert based on a standardized questionnaire using the 1990 US Department of Commerce Census Industrial & Occupational Classification Codes.²⁴

Only 1 supplemental allergen source was coded; if testing results for multiple allergens were positive, the most clinically relevant source was chosen. Supplemental allergens were recorded only if the screening series would have missed that clinically relevant allergen. For example, a reaction to isobornyl acrylate on the supplemental acrylate series in a patient with ACD resulting from use of a continuous glucose sensor would be recorded as a currently relevant supplemental allergen because it does not cross-react with acrylates on the screening series. Similarly, data from a patient with eyelid dermatitis, a positive patch test reaction to pimecrolimus (by testing the patient's pimecrolimus, 1%, cream as is and negative patch test reactions to the inactive ingredients) would be recorded as a currently relevant supplemental substance because pimecrolimus is not an allergen included in the screening series. In contrast, a clinically relevant reaction to eugenol would not be recorded as a supplemental allergen if the patient had reacted to fragrance mix I, which contains eugenol and is present in the screening series. Reactions to supplemental aller-

Table 1. Studies Comparing Screening Series vs Comprehensive Testing

Source [country]	Screening series (No. of allergens)	No. of total patients	No. of patients with positive results for any allergen (% of total)	No. of patients (% of those with positive results)		
				Positive to screening only	Positive to supplemental only	Positive to both screening and supplemental
Screening series of <30 allergens						
Sherertz and Swartz, ⁶ 1993 [US]	Hermal Standard (20)	741	499 (67.3)	179 (35.9)	122 (24.4)	198 (39.7)
Cohen et al, ⁷ 1997 [US]	Hermal Standard (20)	732	363 (49.6)	83 (22.9)	147 (40.5)	133 (36.6)
			CR: 221 (30.2)	57 (25.8 of CR)	93 (42.1 of CR)	71 (32.1 of CR)
Menné et al, ⁸ 1992 [4 European countries] ^a	European Standard (22)	3824 ^b	1811 (47.4)	1004 (55.4)	267 (14.7)	540 (29.8) ^c
Saripalli et al, ⁹ 2003 [US]	T.R.U.E. Test (23)	898	616 (68.6)	157 (25.5)	138 (22.4)	321 (52.1)
			CR: 517 (57.6)	145 (28.0 of CR)	129 (25.0 of CR)	243 (47.0 of CR)
Camacho-Halili et al, ¹⁰ 2011 [US]	T.R.U.E. Test (28)	383	266 (69.5)	120 (31.3) ^d	48 (12.5)	98 (25.6)
Patel and Belsito, ⁴ 2012 [US]	T.R.U.E. Test (28)	2088	1385 (66.3)	382 (27.6)	312 (22.5)	691 (49.9)
			CR: 1206 (57.8)	344 (28.5 of CR)	309 (25.6 of CR)	553 (45.9 of CR)
Screening series of >30 allergens						
Akasya-Hillenbrand et al, ¹¹ 2002 ^e [Turkey]	Extended European Standard (32)	542	280 (51.7)	NR	NR	NR
			CR: 190 (67.9)	163 (85.8 of CR)	27 (14.2 of CR) ^f	NR
Watts et al, ⁵ 2019 [UK]	Extended British Standard (45)	156	CR: 77 (49.4)	67 (87.0 of CR)	10 (13.0 of CR)	NR
Screening series of >50 allergens						
Dear et al, ¹² 2021 [Australia]	Australian Baseline (60)	964	964 (100)	611 (63.4)	131 (13.6)	222 (23.0)
Cohen et al, ¹³ 2008 [US]	NACDG Screening (65)	794	590 (74.3)	386 (65.4)	54 (9.2)	148 (25.1)
Patel and Belsito, ⁴ 2012 [US]	NACDG Screening (65)	2088	1385 (66.3)	595 (43.0)	182 (13.1)	608 (43.9)
			CR: 1206 (57.8)	544 (45.1 of CR)	177 (14.7 of CR)	485 (40.2 of CR)
Landis et al, ¹⁴ 2011 [US]	Mayo Clinic Standard (74)	427	NR	92 (21.5)	19 (4.4)	290 (67.9)
Abbreviations: CR, clinically relevant; NACDG, North American Contact Dermatitis Group; NR, not reported; T.R.U.E., Thin-Layer Rapid-Use Epicutaneous.				screening only (n = 1004) and supplemental only (n = 267).		
^a Includes Denmark, Belgium, Sweden, and the UK.				^d Calculated from article data. Number of patients positive to screening allergens only determined by 218 reacting to 1 or more screening allergen and subtracting 98 who reacted to both screening and supplemental agents.		
^b Calculated from data table in original article but excluded 1 site (London) where supplemental allergen data were not provided.				^e Numbers calculated from percentages reported in article.		
^c Calculated from total positive (n = 1811) and subtracting patients reacting to				^f Combines patients with positive results to personal products (11.6%) and supplemental series (2.6%).		

gens/substances with past or unknown clinical relevance were not recorded.

Study Population

All patients tested in the NACDG screening series were included in this analysis. Study groups were defined as supplement-positive (patients with a clinically relevant patch test reaction to ≥ 1 supplemental allergen/substance) or supplement-negative (patients with no currently relevant reactions to supplemental allergens/substances).

Statistical Analysis

All data were manually entered at a centralized location using Access 2010 software (Microsoft Corp) and Microsoft Excel 2019 (Microsoft Corp). Data analysis was conducted between November 18, 2020, and March 12, 2021. Demographic data are presented according to MOAHLFA guidelines (male sex, occupation, atopic, hand, leg, foot, and age >40 years).²⁵ Occupational relevance and the source of exposure are presented using descriptive analyses. Demographic characteristics were

compared between patients with positive and negative screening results using GraphPad Prism software, version 8.2.1 (GraphPad Software) with a 2-sided χ^2 test, and *P* values <.05 were considered statistically significant.

Results

Of 43 417 patients patch tested according to the NACDG screening series, 9507 individuals (21.9%) had 1 or more currently relevant reactions to a supplemental allergen/substance; of these, 2447 individuals (25.7%) with supplement-positive findings had no currently relevant reactions to allergens used in the NACDG screening series. A mean of 27.8% of supplement-positive patients (n = 1128) had no currently relevant reactions to a 65-allergen series (2001-2008) compared with 24.5% (n = 1319) to a 70-allergen series (2009-2018).

Of 30 313 patients with positive reactions to 1 or more screening and/or supplemental allergen, 20 806 individuals (68.6%) had positive reactions to only NACDG screening se-

Table 2. European Surveillance System on Contact Allergies (MOAHFLA) Index Data of Supplement-Positive and Supplement-Negative Patients^a

Characteristic	No. (%) of patients		OR (95% CI)	P value
	Supplement-positive (n = 9507)	Supplement-negative (n = 33 910)		
Sex				
Women	6608 (69.5)	22 768 (67.1)	NA	NA
Men	2899 (30.5)	11 142 (32.9)	0.90 (0.85-0.94)	<.001
Occupation related ^b	1638 (17.3) ^c	3395 (10.0) ^c	1.87 (1.76-1.99)	<.001
Atopic markers				
History of asthma	1416 (15.0) ^d	5291 (15.6) ^d	0.95 (0.89-1.01)	.11
History of atopic dermatitis	2162 (22.9) ^e	8477 (25.1) ^e	0.89 (0.84-0.93)	<.001
History of seasonal rhinitis	2773 (29.3) ^f	10 216 (30.2) ^f	0.96 (0.46-1.01)	.09
Primary anatomic site				
Hand	2029 (21.4) ^g	7815 (23.1) ^g	0.91 (0.43-0.96)	<.001
Face, total	2856 (30.1) ^g	9559 (28.2) ^g	1.09 (1.04-1.15)	<.001
Face, NOS	1557 (16.4) ^g	5210 (15.4) ^f	NA	NA
Eyelids	828 (8.7) ^g	3024 (8.9) ^g	NA	NA
Lips	420 (4.4) ^g	1146 (3.4) ^g	NA	NA
Eyes	48 (0.5) ^g	161 (0.5) ^g	NA	NA
Nose	3 (0.0)	18 (0.1) ^g	NA	NA
Leg	374 (3.9) ^g	1402 (4.1) ^g	0.95 (0.84-1.07)	.40
Age, >40 y	6279 (66.1) ^h	22 794 (67.3) ^h	0.95 (0.90-0.99)	.03

Abbreviations: MOAHFLA, male sex, occupation, atopic, hand, leg, foot, age greater than 40 years; NA, not applicable; NOS, not otherwise specified; OR, odds ratio.

^a Although the MOAHFLA guidelines are limited to male sex,²⁵ data on women are included here.

^b Occupationally related overall skin condition.

^c Twenty-three supplement-positive patients and 90 supplement-negative patients missing occupational relevance.

^d Forty-five supplement-positive patients and 97 supplement-negative patients

missing diagnosis of asthma.

^e Fifty-seven supplement-positive patients and 132 supplement-negative patients missing diagnosis of atopic dermatitis.

^f Forty-six supplement-positive patients and 98 supplement-negative patients missing diagnosis of seasonal rhinitis.

^g Eight supplement-positive patients and 40 supplement-negative patients missing primary anatomic site.

^h Eight supplement-positive patients and 35 supplement-negative patients missing age from database.

ries allergens, 2447 patients (8.1%) had reactions that were positive to only a supplemental allergen/substance, and 7060 patients (23.3%) had positive reactions to both.

Of the 9507 patients with supplement-positive reactions, 6608 (69.5%) were women and 2899 (30.5%) were men; mean (SD) age was 47.2 (0.54) years. Patients with positive vs negative reactions were significantly less likely to be male (OR, 0.90; 95% CI, 0.85-0.94; $P < .001$), older than 40 years (OR, 0.95; 95% CI, 0.90-0.99; $P = .03$), and/or to have a history of atopic dermatitis (OR, 0.89; 95% CI, 0.84-0.93; $P < .001$). Patients with positive vs negative reactions were significantly less likely to be male (2899 [30.5%] vs 11 142 [32.9%]; $P < .001$), older than 40 years (6279 [66.1%] vs 22 794 [67.3%]; $P = .03$), and/or have a history of atopic dermatitis (2162 [22.9%] vs 8477 [25.1%]; $P < .001$), although absolute differences were small (Table 2).

Anatomic Site and Source of Dermatitis

In 9499 patients with supplement-positive results, the most common primary anatomic site of dermatitis was the face (2856 [30.1%]), followed by the hands (2029 [21.4%]), and scattered/generalized distribution (1645 [17.3%]) (Table 3). Compared with patients who had supplement-negative findings, those with supplement-positive results were significantly more likely to have facial dermatitis (2856 [30.1%] vs 9559 [28.2%]; $P < .001$) but significantly less likely to have hand dermatitis

Table 3. Sites of Dermatitis

Dermatitis site (n = 9499) ^a	No. (%)	
	Primary site	Up to 3 sites ^b
Face, total	2856 (30.1)	4103 (43.2)
Face, NOS	1557 (16.4)	2339 (24.6)
Eyelids	828 (8.7)	1085 (11.4)
Lips	420 (4.4)	584 (6.1)
Eyes	48 (0.5)	87 (0.9)
Nose	3 (0.0)	8 (0.1)
Hand	2029 (21.4)	2468 (26.0)
Scattered generalized	1645 (17.3)	2211 (23.3)
Other ^c	972 (10.2)	2084 (21.9)
Trunk	490 (5.2)	1160 (12.2)
Arm	485 (5.1)	1640 (17.3)
Scalp	381 (4.0)	616 (6.5)
Leg	374 (3.9)	984 (10.4)
Foot	267 (2.8)	550 (5.8)

Abbreviation: NOS, not otherwise specified.

^a Information on dermatitis site was missing for 8 patients.

^b Total percentages may exceed 100% because up to 3 sites per patient could be listed.

^c Includes anal/genital, neck, ears, underclothing, erythroderma, most-exposed areas, NOS.

(2029 [21.4%] vs 7815 [23.1%], $P < .001$), although absolute differences were small (Table 2).

Sources of supplemental allergens/substances are presented in Table 4. Of all sources ($n = 9235$), most were PCPs (4746 [51.4%]). The most common subcategories were cosmetics (1542 [32.5%]), not otherwise specified PCPs (1375 [29.0%]), hair care products (743 [15.7%]), health aids (238 [5.0%]), and sunscreens (235 [5.0%]). The second most frequent category was clothing, wearing apparel, and protective equipment (1674 [18.1%]); common subcategories included clothing (966 [57.7%]) and jewelry (532 [31.8%]).

Occupational Associations

Compared with patients who had supplement-negative reactions, those with supplement-positive reactions had 1.87 times greater odds of having an occupationally related skin condition (1638 [17.3%] vs 3395 [10.0%]; odds ratio, 1.87; 95% CI, 1.76-1.99; $P < .001$) (Table 2). In the supplement-positive group, of 9362 patients with available data, supplemental allergens/substances were occupationally related in 1580 (16.9%). Top occupations in this subgroup included precision production/craft/repair occupations (especially mechanics/repairs), operators/fabricators/laborers (especially machine operators/assemblers/inspectors), and service occupations (especially hairdressers/cosmetologists) (Table 5). The most common sources of occupationally related supplemental allergens/substances in 1533 patients were chemicals and chemical products (622 [40.6%]), especially adhesives, glues, and bonding agents (240 of 349 with allergies to coatings, adhesives, dyes, inks, and photographic and copying chemicals [68.8%]), followed by PCPs (402 [26.2%]) (Table 4).

Discussion

Among patients referred for patch testing, 21.9% had at least 1 relevant reaction to a supplemental allergen/substance; one-quarter of that subgroup did not have any relevant reactions to allergens in the NACDG screening series. More than half of supplemental allergen sources were PCPs, especially cosmetics. Supplement-positive reactions were related to occupation in 16.9% of the patients, especially precision production, craft, and repair workers, and operators, fabricators, and laborers. If only the NACDG screening series were tested; 31.4% of patients with positive reactions to screening and/or supplemental allergens would have had 1 or more clinically relevant allergens missed.

Demographics and Sites of Dermatitis

The majority (69.5%) of supplement-positive patients were women. This percentage is consistent with a 2013 study on PCPs that found the percentage of female users was higher compared with male users for all PCP categories (overall $P < .05$), with the exception of shaving products.²⁶ In addition, PCP-related contact allergy most commonly affects the face and hands,²⁷ which were the most frequently involved sites of dermatitis in our cohort. Comparison of our study demographics with others is limited because these involved

selected populations (Table 1) in contrast to all patients presenting for patch testing (routine testing).

Supplement-Positive Patients

Our study found that 21.9% of all patients referred for patch testing and 31.4% of patients with positive reactions had relevant allergic patch test reactions to at least 1 supplemental allergen/substance, and 8.1% of supplement-positive patients had reactions only to supplemental allergens/substances. Smaller studies reported similar findings for the NACDG screening series of 9.2% (among 590 patients with a positive reaction to a patch-tested allergen or supplemental allergen; relevance not reported)¹³ and 14.7% (of 1206 patients; clinically relevant only).⁴ Studies evaluating other screening series, such as the Australian Baseline¹² and an Extended British Standard⁵ series, found approximately 13% of patients would have had missed allergens if supplemental series were not tested. In addition, smaller screening series, such as T.R.U.E. (Thin-Layer Rapid-Use Epicutaneous Test) panels, miss 1 or more clinically relevant positive reactions in 72% of patients identified by supplemental testing.^{4,9}

Occupational Considerations

Previous studies reported that 26% to 50% of allergens responsible for occupational contact dermatitis are missed by a screening series alone.^{9,28} Screening series are meant for screening a general population. Because workplace exposures and culprit allergens vary widely among occupational groups, patch testing with supplemental allergen series (eg, metalworking fluids, hairdresser series) or workplace materials is indicated. Accordingly, it was not surprising that patients with clinically relevant supplemental allergens were significantly more likely to have occupationally related skin disease.

There were 1580 patients with supplemental allergens deemed occupationally relevant; the most common were precision production, craft, and repair personnel (25.1%, especially mechanics and repairers [$n = 91$]), followed by operators, fabricators, and laborers (24.0%, especially machine operators, assemblers, and inspectors [$n = 228$]). These results might be expected since mechanics and machine operators are at high risk of developing occupational contact dermatitis given the variety of irritant and allergenic substances encountered (eg, adhesives, rubber chemicals, metals, and preservatives).^{29,30} Many of these materials contain undisclosed ingredients. An Australian occupational clinic reported that 20% of their patients (especially machine operators) had reactions only to their work products.³¹ Schubert et al³² evaluated 652 patients with suspected occupational dermatitis and found that mechanics showed the greatest diversity of occupationally relevant sensitizers (including metalworking fluids, epoxy, rubber components, leave-on products, and miscellaneous lubricants); of 143 clinically relevant reactions to workplace materials, 23 were not accompanied by corresponding reactions to commercial patch test preparations.

Of 1533 occupationally related supplemental allergen sources identified in our study, 40.6% were attributed to chemicals and chemical products, most commonly adhesives, glues,

Table 4. Sources of Supplemental Allergens/Substances

Source	No. (%)	
	All sources (N = 9235) ^a	Occupationally relevant sources (n = 1533) ^b
Personal care products	4746 (51.4)	402 (26.2)
Cosmetics	1542 (32.5)	77 (19.2)
Moisturizers, lotions, creams	580 (37.6)	32 (41.6)
Makeup	260 (16.9)	2 (2.6)
Lipsticks	217 (14.1)	4 (5.2)
Perfumes and fragrances	215 (13.9)	25 (32.5)
Cosmetics, NOS	204 (13.2)	13 (16.7)
Deodorants and antiperspirants	58 (3.8)	1 (1.3)
Other	8 (0.5)	0
Personal care products, NOS	1375 (29.0)	31 (7.7)
Hair care products	743 (15.7)	136 (33.8)
Hair dyes	419 (56.4)	0
Shampoos	168 (22.6)	6 (4.4)
Hair care products, NOS	97 (13.1)	32 (23.5)
Perms	31 (4.2)	22 (16.2)
Hair sprays and gels	28 (3.8)	2 (1.5)
Miscellaneous health aids	238 (5.0)	20 (5.0)
Tapes, adhesive bandages, adhesive aids	91 (38.2)	6 (30.0)
Essential oils, massage oils, aromatherapy	78 (32.8)	12 (60.0)
Medical and miscellaneous health devices	35 (14.7)	1 (5.0)
Miscellaneous health aids, NOS	22 (9.2)	1 (5.0)
Orthopedic implants, prostheses	12 (5.0)	0
Sunscreens	235 (5.0)	2 (0.5)
Soaps/cleansers (skin use)	195 (4.1)	64 (15.9)
Liquid/lotion/bar soaps	71 (36.4)	17 (26.6)
Disinfectants (eg, alcohol, povidone-iodine)	52 (26.7)	17 (26.6)
Wipes	16 (8.2)	3 (4.7)
NOS/other	56 (28.7)	27 (42.2)
Nail care products	144 (3.0)	43 (10.7)
Artificial nails	78 (54.2)	30 (70.0)
Nail polish	29 (20.1)	1 (2.3)
Nail adhesives	26 (18.1)	7 (16.3)
Other/NOS	11 (7.6)	5 (11.6)
Dentistry materials and products	154 (3.2)	29 (7.2)
Dentistry materials and products, NOS	48 (31.2)	7 (24.1)
Dental prostheses	41 (26.6)	8 (27.6)
Amalgams and fillings	37 (24.0)	4 (13.8)
Sealants and bonders	28 (18.2)	8 (27.6)
Eye care products	75 (1.6)	1 (0.2)
Oral hygiene products	45 (1.0)	1 (0.2)
Clothing, wearing apparel, protective equipment, textiles	1674 (18.1)	188 (12.3)
Clothing	966 (57.7)	164 (87.2)
Clothing, NOS	471 (28.1)	13 (7.9)
Shoes, boots, sandals, slippers	181 (10.8)	30 (18.3)
Gloves	154 (9.2)	108 (65.9)
Shirts, pants, blouses, dresses, skirts	103 (6.2)	9 (5.5)
Undergarments, swimwear	23 (1.4)	1 (0.6)
Socks, stockings, hose, nylons	17 (1.0)	1 (0.6)
Belts, jackets, accessories, headwear	17 (1.0)	2 (1.2)
Jewelry	532 (31.8)	4 (2.1)

(continued)

Table 4. Sources of Supplemental Allergens/Substances (continued)

Source	No. (%)	
	All sources (N = 9235) ^a	Occupationally relevant sources (n = 1533) ^b
NOS	111 (66.3)	7 (3.7)
Textiles and fabrics	44 (2.6)	8 (4.3)
Safety equipment, miscellaneous (eg, masks, respirators)	12 (0.7)	4 (2.1)
Other/watches	9 (0.5)	1 (0.2)
Drugs/medications	954 (10.3)	34 (2.2)
Medications, topical	862 (90.4)	21 (61.8)
Antibiotics	261 (30.3)	9 (42.9)
Corticosteroids	175 (20.3)	4 (19.0)
Pain relief, analgesics, antipruritics	154 (17.9)	3 (14.3)
Medications, topical NOS	137 (15.9)	4 (19.0)
Antiacne medications	76 (8.8)	0
Antifungal medications	59 (6.8)	1 (4.8)
Medications, oral, intramuscular, subcutaneous	64 (6.71)	9 (26.5)
Drugs/medications other/NOS	28 (2.9)	4 (11.8)
Chemicals and chemical products	756 (8.2)	622 (40.6)
Coatings, adhesives, dyes, inks, photographic and copying chemicals	418 (55.3)	349 (56.1)
Adhesives/glues/bonding agents	295 (70.6)	240 (68.8)
Coatings (paint, lacquer, shellac, varnish, stains)	67 (16.0)	62 (17.8)
Inks	26 (6.2)	25 (7.2)
NOS/other	20 (4.8)	14 (4.0)
Photographic chemicals	10 (2.4)	8 (2.3)
Solvents, oils, lubricants, fuels	169 (22.4)	157 (25.2)
Metalworking fluid, cutting oils	81 (48.0)	75 (47.8)
NOS	33 (19.5)	31 (19.7)
Lubricating oils and greases	32 (18.9)	29 (18.5)
Automotive oils and fluids	14 (8.2)	13 (8.3)
Solvents/degreasers/petroleum distillates/gasoline	9 (5.3)	9 (5.7)
Chemical products	114 (15.1)	90 (14.5)
Miscellaneous chemical mixtures	26 (22.8)	17 (18.9)
Acrylic resins (raw material)	25 (21.9)	19 (21.1)
Epoxy resins (raw material)	17 (14.9)	15 (16.7)
Urethane resins (raw material)	17 (14.9)	17 (18.9)
Phenolic, formaldehyde resins (raw material)	16 (14.0)	15 (16.7)
Miscellaneous chemical products, NOS	13 (11.4)	7 (7.8)
Other chemical products	55 (7.3)	26 (4.2)
Animals, infectious agents, plants, minerals, persons	587 (6.4)	94 (6.1)
Plants, trees, vegetation [living]	289 (49.2)	55 (58.5)
<i>Toxicodendron</i> species	128 (44.3)	2 (3.6)
Flowers	74 (25.6)	29 (52.7)
Other	87 (30.1)	24
Food products, fresh or processed	223 (38.0)	0
Animals, infectious agents, plants, minerals, persons	75 (12.8)	14 (14.9)
Other, unknown, not elsewhere classified	177 (1.9)	29 (1.9)
Soaps, detergents, cleansers, disinfectant, laundry aids (nonskin)	135 (1.5)	64 (4.2)
Building and construction materials, tools, equipment, supplies	120 (1.3)	59 (3.8)
Equipment, instruments, miscellaneous supplies	49 (40.8)	11 (18.6)
Recreational, athletic equipment	32 (65.3)	2 (18.2)
Other	17 (34.7)	9 (81.8)
Building and construction materials	71 (59.2)	48 (81.4)
Machinery and vehicles	35 (0.4)	28 (1.8)

(continued)

Table 4. Sources of Supplemental Allergens/Substances (continued)

Source	No. (%)	
	All sources (N = 9235) ^a	Occupationally relevant sources (n = 1533) ^b
Furniture, fixtures, structures, and surfaces	18 (0.2)	8 (0.5)
Miscellaneous consumer items	14 (0.2)	0
Swimming pool, spa water	13 (0.1)	0
Sewage, waste, debris, scrap	6 (0.1)	5 (0.3)

Abbreviation: NOS, not otherwise specified.

^a Two hundred seventy-two supplement-positive patients were missing information on the source.^b Forty-seven of 1580 patients with occupationally relevant reactions were missing information on the source.

Table 5. Occupations of Patients With an Occupationally Related Supplemental Allergen

Occupation	No. (%)
Patients, No.	1529 ^a
Precision production, craft, repair, No. (%)	384 (25.1)
Mechanics, repairers	91 (23.7)
Miscellaneous	67 (17.4)
Construction	61 (15.8)
Precision assemblers, metal	57 (14.8)
Machinists	51 (13.3)
Supervisors	20 (5.2)
Dental laboratory, medical appliance technicians	15 (3.9)
Other	22 (5.7)
Operators, fabricators, laborers, No. (%)	367 (24.0)
Machine operators, assemblers, inspectors	228 (62.1)
Handlers, equipment cleaners, helpers, laborers	60 (16.3)
Metal, plastic	27 (7.4)
Printing	23 (6.3)
Transportation, material moving occupations	19 (5.2)
Wood, textile	10 (2.7)
Service, No. (%)	302 (19.8)
Barbers, hairdressers, cosmetologists	163 (54.0)
Health service	50 (16.6)
Other	47 (15.6)
Food service	29 (9.6)
Protective service, private household	13 (4.3)
Professional specialty, No. (%)	181 (11.8)
Auxiliary health care workers	68 (37.6)
Writers, artists, entertainers	39 (21.5)
Health diagnosing	35 (19.3)
Teachers	15 (8.3)
Engineers, architects, surveyors, computer scientists	11 (6.1)
Other	13 (7.2)
Technical, sales, administrative support, No. (%)	133 (8.7)
Sales occupations	44 (33.1)
Health technicians	38 (28.6)
Other technicians	31 (23.3)
Administrative support occupations	20 (15.0)
Military occupations, No. (%)	63 (4.1)
Managerial, administrative, No. (%)	57 (3.7)
Farming, forestry, fishing, No. (%)	26 (1.7)

^a Fifty-one patients were missing occupation or were miscoded.

and bonding agents. The NACDG screening series has included the following adhesive allergens: colophony, epoxy resin, p-tert butylphenol formaldehyde resin, methyl methacrylate, ethyl acrylate, 2-hydroethylmethacrylate and/or ethyl cyanoacrylate (some allergens were tested only in certain cycles). Additional important allergens in this group include bis(2-dimethylaminoethyl) ether, 2-hydroxymethyl methacrylate, 2-hydroxyethyl acrylate, and ethylene glycol dimethacrylate.³³

Sources

Sources of supplemental allergens were commonly PCPs, especially cosmetics (n = 1542) and hair care products (n = 743). The value of testing patients with suspected cosmetic allergy to a supplemental cosmetic series is well described.³⁴⁻³⁶ A study of 945 US patients with suspected cosmetic allergy found that the T.R.U.E. Test would have missed 1 or more allergens in 22.5% of patients with preservative allergy, 11.3% with fragrance allergy, and 17.3% with excipient allergy.³⁴ Similarly, Ada and Seçkin³⁵ reported that 30% of 93 patients would have had 1 or more cosmetic series allergens missed if only the European Standard Series was used.

Although commercially available patch test materials (standard and supplementary series) provide the foundation of patch testing, many experts emphasize the necessity of testing PCPs.³⁶⁻³⁸ A European analysis of 5911 patients with cosmetic allergy found that one-third reacted only to 1 or more PCPs and no other allergen.³⁶ Our study underscores the importance of testing with personal and workplace materials.

Approximately one-fifth (18.1%) of patients with supplement-positive findings had reactions to allergens in clothing/wearing apparel. Allergic contact dermatitis due to clothing and/or shoe wear can result from exposure to a variety of agents, including textile dyes, fabric finishes, biocides, metals, rubber additives, glues, or tanning agents.^{39,40} In patients with suspected ACD caused by clothing, patch testing with a specialized textile series is often necessary.^{41,42} An Italian study of 100 patients sensitized to textile dyes found that 24% of patients would have been missed by a screening series that included 4 disperse dyes (disperse blue 124, disperse red 1, disperse orange 3, and disperse yellow 3); testing with an additional 12 textile dyes helped to identify 23% of the cases.⁴³ There are numerous commercial patch test textile dye series available, although testing a patient's personal garments may also be of use, especially when particular dyes

are undeclared or proprietary. Specific allergens reported in footwear dermatitis are variable depending on fashion styles, manufacturing processes, climate, and geographic conditions.⁴⁴ A previous analysis of NACDG data revealed that 29.8% of patients with shoe contact allergy had positive patch test reactions to supplemental allergens and the screening series did not identify the specific shoe allergen in 12.2% of the cases.⁴⁵ Similar to clothing, patch testing for suspected shoe allergy often involves patch testing with samples of patients' own footwear. To avoid false-negative results, it is important to use large pieces of shoes and clothing, moisten with water, and reapply if the result is negative at 48 hours.^{46,47} Extracts of solid objects may also be tested.⁴⁸

Limitations

There are several limitations to this study. First, the source of only 1 supplemental allergen/substance was recorded per patient; if multiple findings were positive, only the most clinically relevant source was coded. Second, specific names of supplemental allergens are not collected in the NACDG database. Third, our data do not specify whether supplemental allergens were obtained from commercial sources or personal or work products. There is also variability in the methods for patch testing PCPs (eg, dilution, vehicle, and occlusion vs semi-

occlusion), which may influence detection. Fourth, although most (>90%) patients were tested for allergic reactions to supplemental series/substances, in some cases, only the NACDG screening series was tested or patients chose not to bring personal items for testing; this information was not recorded; thus, our numbers represent underestimates. Fifth, the study sample was drawn from patients who were referred for patch testing; as such, they are representative of neither the general population nor the general dermatology population.

Conclusions

Our study found that 21.9% of patients with suspected ACD undergoing patch testing had a relevant reaction to at least 1 supplemental allergen/substance; of these, one-quarter had no currently relevant reactions to the NACDG screening series. These findings highlight the limitations of testing in a screening series alone. Based on exposure and occupational history, comprehensive patch testing includes testing not only supplemental allergens but also PCPs and workplace materials. These results suggest that comprehensive patch testing would be useful for the diagnosis and management of contact allergy.

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REFERENCES

1. Belsito DV. Patch testing: after 100 years, still the gold standard in diagnosing cutaneous delayed-type hypersensitivity. *Arch Paul Ehrlich Inst Bundesamt Sera Impfstoffe Frankfurt A.M.* 1997;(91):195-202.
2. Yu DS, Kim HJ, Park YG, Bae JM, Kim J-W, Lee YB. Patch-test results using Korean standard series: a 5-year retrospective review. *J Dermatolog Treat.* 2017;28(3):258-262. doi:10.1080/09546634.2016.1219015
3. Schallock PC, Dunnick CA, Nedorost S, et al; American Contact Dermatitis Society Core Allergen Series Committee. American Contact Dermatitis Society Core Allergen Series: 2020 update. *Dermatitis.* 2020;31(5):279-282. doi:10.1097/DER.0000000000000621
4. Patel D, Belsito DV. The detection of clinically relevant contact allergens with a standard screening tray of 28 allergens. *Contact Dermatitis.* 2012;66(3):154-158. doi:10.1111/j.1600-0536.2011.02022.x
5. Watts TJ, Watts S, Thursfield D, Haque R. A patch testing initiative for the investigation of allergic contact dermatitis in a UK allergy practice: a retrospective study. *J Allergy Clin Immunol Pract.* 2019;7(1):89-95. doi:10.1016/j.jaip.2018.08.030
6. Sherertz EF, Swartz SM. Is the screening patch test tray still worth using? *J Am Acad Dermatol.* 1993;29(6):1057-1058. doi:10.1016/S0190-9622(08)82052-X
7. Cohen DE, Brancaccio R, Andersen D, Belsito DV. Utility of a standard allergen series alone in the evaluation of allergic contact dermatitis:

- a retrospective study of 732 patients. *J Am Acad Dermatol*. 1997;36(6, pt 1):914-918. doi:10.1016/S0190-9622(97)80272-1
8. Menné T, Dooms-Goossens A, Wahlberg JE, White IR, Shaw S. How large a proportion of contact sensitivities are diagnosed with the European standard series? *Contact Dermatitis*. 1992;26(3):201-202. doi:10.1111/j.1600-0536.1992.tb00299.x
 9. Saripalli YV, Achen F, Belsito DV. The detection of clinically relevant contact allergens using a standard screening tray of twenty-three allergens. *J Am Acad Dermatol*. 2003;49(1):65-69. doi:10.1067/mjd.2003.489
 10. Camacho-Hallil MA, Axelrod S, Michelis MA, et al. A multi-center, retrospective review of patch testing for contact dermatitis in allergy practices. *Ann Allergy Asthma Immunol*. 2011;107(6):487-492. doi:10.1016/j.anaai.2011.09.004
 11. Akasya-Hillenbrand E, Ozkaya-Bayazit E. Patch test results in 542 patients with suspected contact dermatitis in Turkey. *Contact Dermatitis*. 2002;46(1):17-23. doi:10.1034/j.1600-0536.2002.460104.x
 12. Dear K, Bala H, Palmer A, Nixon RL. How good is the Australian baseline series at detecting allergic contact dermatitis? *Australas J Dermatol*. 2021;62(1):51-56. doi:10.1111/ajd.13456
 13. Cohen DE, Rao S, Brancaccio RR. Use of the North American Contact Dermatitis Group Standard 65-allergen series alone in the evaluation of allergic contact dermatitis: a series of 794 patients. *Dermatitis*. 2008;19(3):137-141. doi:10.2310/6620.2008.06061
 14. Landis M, Nordberg-Linehan D, Keeling J, et al. Patch testing with supplemental allergens in conjunction with the standard series yields more reactions than the standard series alone. *J Am Acad Dermatol*. 2011;64(2):AB64-AB64. doi:10.1016/j.jaad.2010.09.284
 15. Pratt MD, Belsito DV, DeLeo VA, et al. North American Contact Dermatitis Group patch-test results, 2001-2002 study period. *Dermatitis*. 2004;15(4):176-183.
 16. Rietschel RL, Warshaw EM, Sasseville D, et al. North American Contact Dermatitis Group. Common contact allergens associated with eyelid dermatitis: data from the North American Contact Dermatitis Group 2003-2004 study period. *Dermatitis*. 2007;18(2):78-81. doi:10.2310/6620.2007.06041
 17. Zug KA, Warshaw EM, Fowler JF Jr, et al. Patch-test results of the North American Contact Dermatitis Group 2005-2006. *Dermatitis*. 2009;20(3):149-160. doi:10.2310/6620.2009.08097
 18. Fransway AF, Zug KA, Belsito DV, et al. North American Contact Dermatitis Group patch test results for 2007-2008. *Dermatitis*. 2013;24(1):10-21. doi:10.1097/DER.0b013e3182877ca50
 19. Warshaw EM, Belsito DV, Taylor JS, et al. North American Contact Dermatitis Group patch test results: 2009 to 2010. *Dermatitis*. 2013;24(2):50-59. doi:10.1097/DER.0b013e3182819c51
 20. Warshaw EM, Maibach HI, Taylor JS, et al. North American contact dermatitis group patch test results: 2011-2012. *Dermatitis*. 2015;26(1):49-59. doi:10.1097/DER.0000000000000097
 21. DeKoven JG, Warshaw EM, Belsito DV, et al. North American Contact Dermatitis Group patch test results 2013-2014. *Dermatitis*. 2017;28(1):33-46. doi:10.1097/DER.0000000000000225
 22. DeKoven JG, Warshaw EM, Zug KA, et al. North American Contact Dermatitis Group patch test results: 2015-2016. *Dermatitis*. 2018;29(6):297-309. doi:10.1097/DER.0000000000000417
 23. DeKoven JG, Silverberg JI, Warshaw EM, et al. North American Contact Dermatitis Group patch test results: 2017-2018. *Dermatitis*. 2021;32(2):111-123.
 24. Census Industrial & Occupational Classification Codes. *NLSY97 Codebook Supplement: NLSY97 Attachment 1*. US Dept of Commerce Bureau of the Census; 1990.
 25. Uter W, Schnuch A, Gefeller O; ESCD Working Group: European Surveillance System on Contact Allergies. Guidelines for the descriptive presentation and statistical analysis of contact allergy data. *Contact Dermatitis*. 2004;51(2):47-56. doi:10.1111/j.0105-1873.2004.00406.x
 26. Biesterbos JW, Dudzina T, Delmaar CJ, et al. Usage patterns of personal care products: important factors for exposure assessment. *Food Chem Toxicol*. 2013;55:8-17. doi:10.1016/j.fct.2012.11.014
 27. Zirwas MJ. Contact dermatitis to cosmetics. *Clin Rev Allergy Immunol*. 2019;56(1):119-128. doi:10.1007/s12016-018-8717-9
 28. Nettis E, Marcandrea M, Colanardi MC, Paradiso MT, Ferrannini A, Tursi A. Results of standard series patch testing in patients with occupational allergic contact dermatitis. *Allergy*. 2003;58(12):1304-1307. doi:10.1046/j.1398-9995.2003.00346.x
 29. Schwensen JF, Friis UF, Menné T, Johansen JD. One thousand cases of severe occupational contact dermatitis. *Contact Dermatitis*. 2013;68(5):259-268. doi:10.1111/cod.12045
 30. Larese Filon F, Delneri A, Rui F, Bovenzi M, Mauro M. Contact dermatitis in Northeast Italy mechanics (1996-2016). *Dermatitis*. 2019;30(2):150-154. doi:10.1097/DER.0000000000000456
 31. Slodownik D, Williams J, Frowen K, Palmer A, Matheson M, Nixon R. The additive value of patch testing with patients' own products at an occupational dermatology clinic. *Contact Dermatitis*. 2009;61(4):231-235. doi:10.1111/j.1600-0536.2009.01610.x
 32. Schubert S, Geier J, Skudlik C, et al. Relevance of contact sensitizations in occupational dermatitis patients with special focus on patch testing of workplace materials. *Contact Dermatitis*. 2020;83(6):475-486. doi:10.1111/cod.13688
 33. Shmidt E, Farmer SA, Davis MD. Patch-testing with plastics and glues series allergens. *Dermatitis*. 2010;21(5):269-274. doi:10.2310/6620.2010.10024
 34. Wetter DA, Yiannias JA, Prakash AV, Davis MDP, Farmer SA, el-Azhary RA. Results of patch testing to personal care product allergens in a standard series and a supplemental cosmetic series: an analysis of 945 patients from the Mayo Clinic Contact Dermatitis Group, 2000-2007. *J Am Acad Dermatol*. 2010;63(5):789-798. doi:10.1016/j.jaad.2009.11.033
 35. Ada S, Seçkin D. Patch testing in allergic contact dermatitis: is it useful to perform the cosmetic series in addition to the European standard series? *J Eur Acad Dermatol Venereol*. 2010;24(10):1192-1196. doi:10.1111/j.1468-3083.2010.03619.x
 36. Uter W, Balzer C, Geier J, Frosch PJ, Schnuch A. Patch testing with patients' own cosmetics and toiletries—results of the IVDK, 1998-2002. *Contact Dermatitis*. 2005;53(4):226-233. doi:10.1111/j.0105-1873.2005.00690.x
 37. Daecke CM, Schaller J, Goos M. Value of the patient's own test substances in epicutaneous testing. Article in German. *Hautarzt*. 1994;45(5):292-298. doi:10.1007/s001050050072
 38. Tous-Romero F, Ortiz Romero PL, de Frutos JO. Usefulness of patch testing with patient's own products in the diagnosis of allergic contact dermatitis. *Dermatitis*. 2021;32(1):38-41. doi:10.1097/DER.0000000000000654
 39. Svedman C, Engfeldt M, Malinauskiene L. Textile contact dermatitis: how fabrics can induce dermatitis. *Curr Treat Options Allergy*. 2019; 6:103-111. doi:10.1007/s40521-019-0197-5
 40. Matthys E, Zahir A, Ehrlich A. Shoe allergic contact dermatitis. *Dermatitis*. 2014;25(4):163-171. doi:10.1097/DER.0000000000000049
 41. Wentworth AB, Richardson DM, Davis MD. Patch testing with textile allergens: the Mayo Clinic experience. *Dermatitis*. 2012;23(6):269-274. doi:10.1097/DER.0b013e318277ca3d
 42. Heratizadeh A, Geier J, Molin S, Werfel T. Contact sensitization in patients with suspected textile allergy: data of the Information Network of Departments of Dermatology (IVDK) 2007-2014. *Contact Dermatitis*. 2017;77(3):143-150. doi:10.1111/cod.12760
 43. Seidenari S, Manzini BM, Danese P. Contact sensitization to textile dyes: description of 100 subjects. *Contact Dermatitis*. 1991;24(4):253-258. doi:10.1111/j.1600-0536.1991.tb01718.x
 44. Landeck L, Uter W, John SM. Patch test characteristics of patients referred for suspected contact allergy of the feet—retrospective 10-year cross-sectional study of the IVDK data. *Contact Dermatitis*. 2012;66(5):271-278. doi:10.1111/j.1600-0536.2012.02046.x
 45. Atwater AR, Bembry R, Green CL, et al. Shoe allergens: a retrospective analysis of cross-sectional data from the North American Contact Dermatitis Group, 2005-2018 [abstract]. *Dermatitis*. 2021;32(3):e46-e59. doi:10.1097/DER.0000000000000757
 46. Epstein E. Shoe contact dermatitis. *JAMA*. 1969;209(10):1487-1492. doi:10.1001/jama.1969.03160230021005
 47. Jordan WP. 24-, 48-, and 48/48-Hour patch tests. *Contact Dermatitis*. 1980;6(2):151-152. doi:10.1111/j.1600-0536.1980.tb03939.x
 48. Schlarbaum JP, Kimyon RS, Liou YL, Neeley AB, Warshaw EM, Hylwa SA. Our approach to textile dermatitis: in-clinic dye extraction. *Dermatitis*. 2021;32(1):e14-e15. doi:10.1097/DER.0000000000000652