

Contact Dermatitis Associated With Nail Care Products: Retrospective Analysis of North American Contact Dermatitis Group Data, 2001–2016

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Background: Ingredients in nail care products may lead to allergic and/or irritant contact dermatitis.

Objective: The aims of this study were to determine frequency of contact dermatitis associated with nail care products, characterize associated body sites, and describe causative allergens.

Methods: A retrospective analysis was conducted with the North American Contact Dermatitis Group data between 2001 and 2016.

Results: Of the 38,775 patients tested, 769 (2.0%) had: 1) more than 1 allergic patch test reaction associated with a nail care product (n = 746), 2) irritant contact dermatitis associated with a nail care product (n = 14), or 3) both (n = 9). Primary body sites included the face (43.0%) and hands (27.6%). The top 5 allergens were (2-hydroxyethyl methacrylate (273/482, 56.6%), methyl methacrylate (210/755, 27.8%), ethyl acrylate (190/755, 25.2%), ethyl-2-cyanoacrylate (12/175, 6.9%) and tosylamide (273/755, 36.2%). Frequency of allergy to 2-hydroxyethyl methacrylate ($P = 0.0069$) and ethyl acrylate ($P = 0.0024$) significantly increased over the study period, whereas allergy secondary to tosylamide significantly decreased ($P < 0.0001$).

Conclusions: As long-lasting nail techniques become widespread, the prevalence of contact dermatitis to nail care products is expected to increase. Almost one-fifth of nail care product-associated allergens would have been missed without additional screening allergens beyond the North American Contact Dermatitis Group series, underscoring the need for testing to a broad array of allergens.

Nail care products have long been used cosmetically. Embellishments include liquid nail polish, nail wraps, gel nails, dipping powders, and acrylics (Table 1). Nail care products may also be used

to strengthen the nail plate, soften cuticles, and promote nail hydration.¹ These products are popular; spending on nail salon services in the United States was estimated to be at least \$8.5 billion in 2017.²

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TABLE 1. Descriptions of Common Nail Techniques^{1,2}

Nail Care Product	Synonyms	Process	Approximate Duration
Nail polish	Nail varnish Nail lacquer	Liquid nail polish painted onto the nail plate or as a finish on top of acrylic or gel nails, with or without base and top coats. Applied at home and in salons.	1 wk
Nail wraps	Preformed nails Silk nails	Decorative sheets applied to the nail plate with cyanoacrylate-based nail glue or adhesive backing; sheets then warmed and trimmed/ filed to accommodate shape of the nail. Applied at home and in salons.	1–2 wk
Press-on nails	Fake/false nails Stick-on nails	False plastic nails applied to the nail plate with cyanoacrylate-based nail glue or adhesive backing. Applied at home and in salons.	1–2 wk
Gel nail polish	Gel nail polish Long-lasting nail polish Semipermanent nail polish Shellac gel nail polish*	Gel polish consisting of acrylic monomers painted onto the nail plate or as a finish on top of acrylic or gel nails, which is usually cured with UV or LED light. At least 3 layers are typically applied (base and top coats are clear). Each layer contains acrylic monomers, and after application of each layer, exposure to UV (approximately 2 min) or LED light source (approximately 30 s) is usually needed for polymerization. Applied at home and in salons.	2 wk
Acrylic nails	Porcelain nails	Liquid acrylic monomers mixed with powder polymers and sculpted onto the nail plate. Applied in salons.	2–3 wk
Powder nails	Dipped nails Dipping powders	Cyanoacrylate-based nail glue applied to the nail plate, dipped into polymer powder, and hardened with a water-based activator. Applied in salons.	3–4 wk

*A specific brand of gel nail polish that may not require light curing.

This estimate does not include data from smaller nail salons or the cost of newer, do-it-yourself, home gel nail polish products.

Nail treatments may lead to adverse effects. Irritant contact dermatitis (ICD) can result in nail plate yellowing, nail dystrophy, and cuticle disruption.³ Allergic contact dermatitis (ACD) to nail polish in consumers has been reported to most commonly present as eczematous dermatitis involving the face and neck, as allergens are transferred by direct contact from partially dried polish.^{4,5} Özkaya and Ekinci⁶ estimated the prevalence of nail polish allergy in a Turkish population at 1% of all patch-tested patients. The prevalence was notably higher in Brazil, where 8% of patients with presumed ACD had patch test reactions to at least 1 nail polish ingredient.⁷

Historically, tosylamide—a synthetic resin added to polish to enhance flexibility and shine—has been the most common nail polish-associated allergen.^{2,8} However, the prevalence of ACD to tosylamide may be declining, largely due to a shift toward newer “hypoallergenic” or “tosylamide-free” polish alternatives.⁹ Contact allergy to (meth)acrylate chemicals, conversely, is on the rise.^{10,11} Many authors attribute this increase to emerging long-lasting nail techniques such as gel nail polishes, some of which utilize a light-based curing system to induce polish hardening.^{1,12,13} Although fully cured (meth)acrylate polymers are thought to rarely cause cutaneous sensitization, monomers have significant allergenic potential.¹² Sensitization occurs when polish is cured inadequately and residual monomers contact the skin.^{14,15} Select literature on the prevalence of contact allergy specifically to nail care products associated with tosylamide and (meth)acrylates is summarized in Table 2. In addition to these well-known allergens, other contact sensitizers associated with nail care products include cyanoacrylates, formaldehyde (and related compounds), phthalates, benzophenones, and epoxy resin.^{12,18,19}

Although previous studies have investigated ACD to nail care products, updated estimates from a large US cohort have been lacking. Our primary goals were to determine (1) the frequency of nail care products as a source of clinically relevant positive patch test reactions, (2) the frequency of nail care products as a source of ICD, (3) primary body sites affected in nail care product-associated dermatitis, and (4) commonly associated allergens and nail care product sources among patients patch tested by the North American Contact Dermatitis Group (NACDG).

MATERIALS AND METHODS

NACDG Database

Deidentified data from the NACDG screening series database between 2001 and 2016 were analyzed. Patch testing was conducted in accordance with NACDG standards, which have been described previously.²⁰ Collected data included patient demographics (age, sex, race, occupation), history of atopy (asthma, eczema, hay fever), body sites of dermatitis (maximum of 3 sites), final diagnosis (maximum of 3 diagnoses), and associated allergens. The number of tested allergens varied by 2-year cycle. Sixty-five allergens were tested between 2001 and 2006 and 70 allergens between 2007 and 2016; not all allergens were tested during every cycle. For each patch test reaction, clinical relevance, occupational relevance, strength of reaction, and source codes were documented. Current relevance encompassed reactions coded as “definite” (positive patch test or use test with a skin contactant verified to contain the allergen), “probable” (allergen verified in skin contactant with a consistent clinical presentation), and “possible” (skin contactant possibly contained the allergen); past relevance included previous exposures

TABLE 2. Select Literature on the Prevalence of Sensitization to Tosylamide and (Meth)acrylates Associated With Nail Care Products

Study	Country	Study Period	No. Patients	Frequency of Positive Reactions Related to Nail Care Products	Comments
Tosylamide					
Tosti et al ⁸	Italy	1987–1992	888 women	6.64%	59 patients Female: 100% Occupational: NR Average age: 31 y Hand: 3.4% Face: 40.7%
Lazzarini et al ⁷	Brazil	1996–2006	1971 general patch test patients	8.0%	157 patients Female: 100% Occupational: 9% Average age: 31.6 y 90% positive to tosylamide, 6% positive to tosylamide and formaldehyde
Özkaya and Ekinci ⁶	Turkey	1996–2008	1607 general patch test patients	1.0%	16 patients Female: 93.8% Average age: 28.7 y 87.5% positive to tosylamide and/or their own nail polish 8 additional patients with relevant nickel allergy
Lee et al ⁹	Australia	2002–2017	7408 general patch test patients	0.78%	58 patients with tosylamide reactions related to nail polish use. Significant decrease in reactions over 16 y ($P < 0.001$). High in 2005 1.9% to 0 in 2017
Current study	United States, Canada	2001–2016	38,775 general patch test patients	0.70%	273 patients* Female: 97.8% Occupational: 5.5% Average age: 51.7 y Hand: 13.6% Face: 58.2% Significant decrease in reactions over 16 y ($P < 0.001$). High in 2005–2006, 0.97% to 0.39% in 2015–2016
(Meth)acrylates					
Montgomery et al ¹⁵	United Kingdom	2008–2014	4710 general patch test patients	1.15%	54 patients Female: 91% Occupational: 31.5% Average age: 40 y Hand: 23% Face: 43% HEMA: 81.2%

(Continued on next page)

TABLE 2. (Continued)

Study	Country	Study Period	No. Patients	Frequency of Positive Reactions Related to Nail Care Products	Comments
Raposo et al ¹²	Portugal	2011–2015	11,639 general patch test patients	1.97%	230 patients Female: 100% Occupational: ~50% Average age: 36.9 y Hand: 93.0% Face: 35.2% HEMA: 90% HPMA: 64.1% EGDMA: 54.5%
Gatica-Ortega et al ¹¹	Spain	2013–2016	2353 general patch test patients	1.82%	43 patients using long-lasting nail polish only; excluded acrylic nails and other nail products. Female: 100% Occupational: 93% Average age: 35 y Hand: 100% Face: 37.5% HPMA: 95.3% HEMA: 90.7% THFMA: 79.5% HEA: 75.9%
Gonçalo et al ¹⁷	Belgium, Denmark, Germany, Finland, Italy, Portugal, Spain, Sweden, United Kingdom	2013–2015	18,228 general patch test patients	0.75%	136 patients Female: 99.3% Occupational: 56.6% Average age: 36.7 y Hand: 88.9% Face: 36.8% HEMA: 91.9% HPMA: 83.2% EGDMA: 69.2% TEGDMA: 31.6% MMA: 26.3% ECA: 9.9%
Current study	United States, Canada	2001–2016	38,775 general patch test patients	1.10%	425 patients* Female: 98.4% Occupational: 15.6% Average age: 51.7 y Hand: 35.3% Face: 33.9% HEMA: 64.2%† MMA: 49.4%† EA: 44.7%†

*Includes patients with overlapping tosylamide and acrylate reactions.

†Denominator is total number of patients with acrylate reactions.

NR indicates not reported.

likely containing the allergen in question. Occupation was coded using the 1980 Census Classified Index of Industries and Occupations.²¹ Occupational relevance was determined from history and clinical presentation. For each positive allergen, an exposure source was classified. Sources were also coded for positive relevant non-NACDG

nail care product-associated allergens, although the names of those specific allergens were not recorded.

In addition to allergens, an assessment of ICD (based on clinical history and examination) was coded for each patient. If an irritant was considered clinically relevant, the source of ICD was coded.

Study Population

Nail care products (nail polish/coatings/gels/strengtheners, artificial nails/extendors, nail adhesives, nail moisturizers, and nail care products not otherwise specified) were added as source codes to the NACDG database in 2001; the study population therefore consisted of NACDG patch-tested patients between 2001 and 2016. Patients with nail care product sources specifically associated with any of the following were included: (1) positive patch test reaction to an NACDG screening allergen, (2) positive patch test reaction to a non-NACDG allergen, and (3) ICD. Allergens with both current and past clinical relevance were included. Patients with reactions of unknown clinical relevance or with negative final readings were excluded. Patients with reactions to nail allergens associated with a non-nail care product source (eg, methyl methacrylate [MMA] allergic reaction associated with a dental adhesive source) were not included.

Data Analysis

Data were entered at a centralized location using Access software (Access 2010; Microsoft Corporation, Redmond, WA) and subsequently analyzed with Microsoft Excel (Excel 2019; Microsoft Corporation). Demographics, clinical relevance, occupational relevance, strength of reactions, and exposure sources were presented using descriptive analyses including frequencies, counts, and proportions. Allergens and sources were compared using χ^2 test with GraphPad Prism software (version 8.2.1 for Mac OS X; GraphPad Software, La Jolla, CA). The Cochran-Armitage test was used to evaluate trends over time (eight 2-year cycles; SAS System; SAS Institute, Cary, NC). $P < 0.05$ was considered statistically significant.

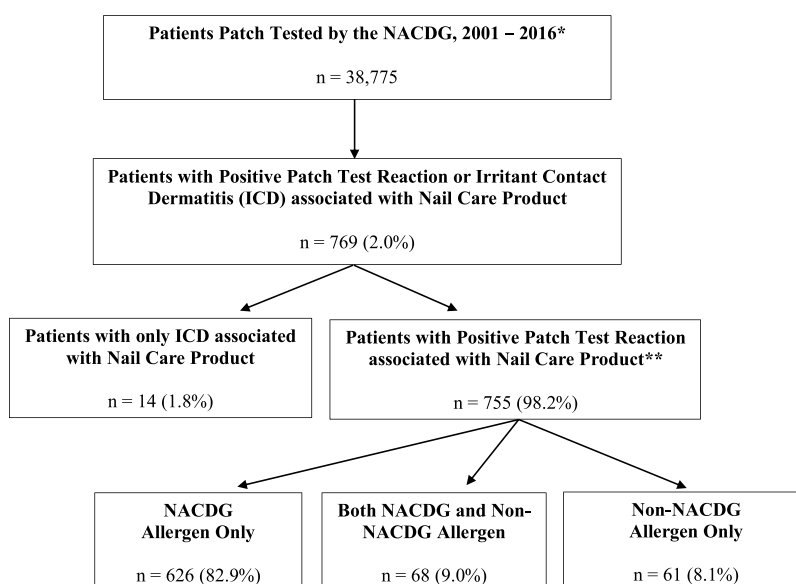
RESULTS

Frequency of Sensitivity

Of the 38,775 patients patch tested between 2001 and 2016, 769 patients (2.0%) had clinically relevant positive patch test reactions and/or ICD associated with a nail care product (Fig. 1). Of these 769 patients, 746 patients (97.0%) had allergic reactions only, 14 patients (1.8%) had ICD only, and 9 patients (1.2%) had both. Of those with allergic patch test reactions attributed to a nail care product, 17.1% had reactions to allergens not on the NACDG screening series. As compared with the previous 7 cycles, the most recent cycle found a significant increase in overall nail care product reactions (1.9% vs 2.4%, $P = 0.0171$).

Demographics and Primary Sites of Involvement

Patient demographics are listed in Table 3. Most patients were female, white, and older than 40 years. Overall occupational relevance was found in 98 of 767 patients (12.8%). The most common occupation was hairdressers/cosmetologists (includes nail technicians; 66.3%). Nail care product allergy was most commonly associated with dermatitis involving the face (43.0%; with the eyelids affected in 14.4% of patients), hands (27.6%), or a scattered/generalized distribution (12.1%; Table 4). Subgroup analysis of individuals with only tosylamide or only (meth)acrylate allergy (excluding those with both) found that patients with tosylamide allergy had significantly greater involvement of the face as compared with those with (meth)acrylate allergy (60.5% vs 33.2%, $P < 0.0001$), whereas those with (meth)acrylate allergy had greater involvement of the hands (35.8% vs 10.9%, $P < 0.0001$).



*NACDG = North American Contact Dermatitis Group

**Excludes patients with allergens of unknown clinical relevance and negative final readings. Includes 9 patients with both nail care products as allergen sources and irritant contact dermatitis associated with nail care products.

Figure 1. Participant flow diagram.

TABLE 3. Demographics of Patients With an Allergic Patch Test Reaction or ICD Associated With a Nail Care Product

	Total, n (%) [*] n = 769	Allergic Patch Test Reaction†		ICD, n (%) [*] n = 14
		Current Relevance, n (%) [*] n = 586	Past Relevance, n (%) [*] n = 169	
Sex				
Female	750 (97.5)	571 (97.4)	165 (97.6)	14 (100.0)
Age, y				
Mean age	51.5	51.4	51.8	51.8
<18	8 (1.0)	6 (1.0)	2 (1.2)	0 (0.0)
19–39	149 (19.4)	114 (19.5)	29 (17.2)	6 (42.9)
40–59	384 (50.0)	292 (49.9)	87 (51.5)	5 (35.7)
60	227 (29.6)	173 (29.6)	51 (30.2)	3 (21.4)
Race				
White	670 (87.7)	504 (86.6)	154 (91.7)	12 (85.7)
Black	41 (5.4)	33 (5.7)	8 (4.8)	0 (0.0)
Asian	35 (4.6)	32 (5.5)	2 (1.2)	1 (7.1)
Hispanic	9 (1.2)	7 (1.2)	2 (1.2)	0 (0.0)
Other	9 (1.2)	6 (1.0)	2 (1.2)	1 (7.1)
Atopy				
Hay fever	231 (30.1)	163 (27.9)	63 (37.3)	5 (35.7)
Eczema	185 (24.2)	124 (21.3)	59 (34.9)	2 (14.3)
Asthma	122 (15.9)	89 (15.2)	32 (18.9)	1 (7.1)
Primary diagnosis‡				
ACD	650 (84.9)	533 (91.4)	113 (66.9)	4 (28.6)
Atopic dermatitis	40 (5.2)	19 (3.3)	21 (12.4)	0 (0.0)
ICD	24 (3.1)	10 (1.7)	7 (4.1)	7 (50.0)
Other dermatitis	32 (4.2)	13 (2.2)	18 (10.7)	1 (7.1)
Other dermatoses	20 (2.6)	8 (1.4)	10 (5.9)	2 (14.3)
Occupationally related				
No/unsure	669 (87.2)	499 (85.3)	158 (94.0)	12 (85.7)
Yes	98 (12.8)	86 (14.7)	10 (6.0)	2 (14.3)

^{*}Available data varied slightly for each demographic variable; denominator adjusted accordingly.

†Includes 9 patients with both nail care products as allergen sources and ICD associated with nail care products.

‡Up to 3 diagnoses could be coded, but only the primary diagnosis is listed in the table.

Allergens

The top 5 NACDG screening allergens associated with nail care products were (2-hydroxyethyl methacrylate [2-HEMA] [273/482, 56.6%], MMA [210/755, 27.8%], ethyl acrylate [EA] [190/755, 25.2%], ethyl-2-cyanoacrylate [ECA] [12/175, 6.9%]) and tosylamide (273/755, 36.2%; Table 5). Of patients with reactions to nail care products, the percentage of patients with a positive patch test reaction to 2-HEMA ($P = 0.0069$) and EA ($P = 0.0024$) significantly increased over the study period, whereas allergy secondary to tosylamide significantly decreased ($P < 0.0001$; Fig. 2). Frequency of positive reactions to MMA did not significantly change over time ($P = 0.5329$). Other allergens, including epoxy, fragrance chemicals, and formaldehyde-releasing preservatives, demonstrated frequencies less than 2%.

Reaction strength noted at final patch test reading and clinical relevance of the top 5 allergens are summarized in Table 5. More than half of all reactions to 2-HEMA, tosylamide, and MMA were

++ or +++; EA and ECA were most commonly +. The majority of reactions were of current relevance. 2-Hydroxyethyl methacrylate (16.5%) and EA (15.3%) were most commonly related to occupation. The number of occupationally related positive patch test reactions to EA ($P = 0.0078$) and MMA ($P = 0.0075$) significantly increased over the study period, whereas occupationally related positive patch test reactions to 2-HEMA ($P = 0.5507$) and tosylamide ($P = 0.0774$) did not significantly change over time.

Allergen Sources

Artificial nails, nail polishes/coatings/gels/strengtheners, and nail adhesives were the most common sources (Table 6). Artificial nails were primarily responsible for patch test reactions to 2-HEMA (69.6%), MMA (66.2%), and EA (62.6%). Most reactions to tosylamide were associated with nail polish (83.9%), whereas the primary source for ECA was nail adhesives (50.0%).

TABLE 4. Primary Body Site of Involvement Among Patients With a Positive Patch Test Reaction or ICD Associated With a Nail Care Product

Primary Body Site*	Total, n (%) n = 769	Positive Patch Test Reaction†		ICD, n (%) n = 14
		Current Relevance, n (%) n = 586	Past Relevance, n (%) n = 169	
Face	331 (43.0)	264 (45.1)	60 (35.5)	7 (50.0)
Face, NOS	193 (25.1)	160 (27.3)	29 (17.2)	4 (28.6)
Eyelids	111 (14.4)	84 (14.3)	24 (14.2)	3 (21.4)
Lips	17 (2.2)	12 (2.0)	5 (3.0)	0 (0.0)
Ears	6 (0.8)	4 (0.7)	2 (1.2)	0 (0.0)
Eyes	4 (0.5)	4 (0.7)	0 (0.0)	0 (0.0)
Hand	212 (27.6)	168 (28.7)	37 (21.9)	7 (50.0)
Scattered generalized	93 (12.1)	66 (11.3)	27 (16.0)	0 (0.0)
Neck/scalp	40 (5.2)	30 (5.1)	10 (5.9)	0 (0.0)
Trunk	34 (4.4)	19 (3.2)	15 (8.9)	0 (0.0)
Leg/foot	22 (2.9)	11 (1.9)	11 (6.5)	0 (0.0)
Arm	14 (1.8)	9 (1.5)	5 (3.0)	0 (0.0)
Anal/genital	7 (0.9)	6 (1.0)	1 (0.6)	0 (0.0)
Other	16 (2.1)	13 (2.2)	3 (1.8)	0 (0.0)

*Up to 3 body sites could be coded, but only the primary site of involvement is listed in the table.

†Includes 9 patients with both nail care products as allergen sources and ICD associated with nail care products.

NOS indicates not otherwise specified.

Irritant Contact Dermatitis

Twenty-three (3.0%) of 769 patients had ICD (14 patients with ICD only and 9 with both ICD and ACD attributed to nail care product sources). Irritant contact dermatitis was most commonly associated with artificial nails/extendors (39.1%), nail adhesives (34.8%), and nail care products not otherwise specified (13.0%). Nail adhesives caused a significantly greater proportion of irritant reactions as compared with allergic (34.8% vs 12.4%, respectively; $P = 0.0014$), although these numbers were small ($n = 12$).

DISCUSSION

This retrospective study demonstrated several key findings. Nail care products represented a small portion of overall reactions;

2.0% of all NACDG patch-tested patients had positive patch test reactions or ICD linked to a nail care product source. The predominant body sites of nail care product-associated dermatitis were the face (especially tosylamide) and hands (especially [meth]acrylates) or included a scattered/generalized distribution. The top 5 allergens associated with nail care products were 2-HEMA, MMA, EA, ECA and tosylamide; notably, none of these top 5 allergens are present on T.R.U.E. Test.²² The prevalence of allergy secondary to tosylamide decreased significantly over the study period, whereas 2-HEMA and EA allergy increased. Finally, nearly one-fifth of all nail care product-associated allergens would have been missed without additional screening beyond the NACDG screening series, underscoring the need for testing to a broad array of allergens in suspected allergy to nail care products.

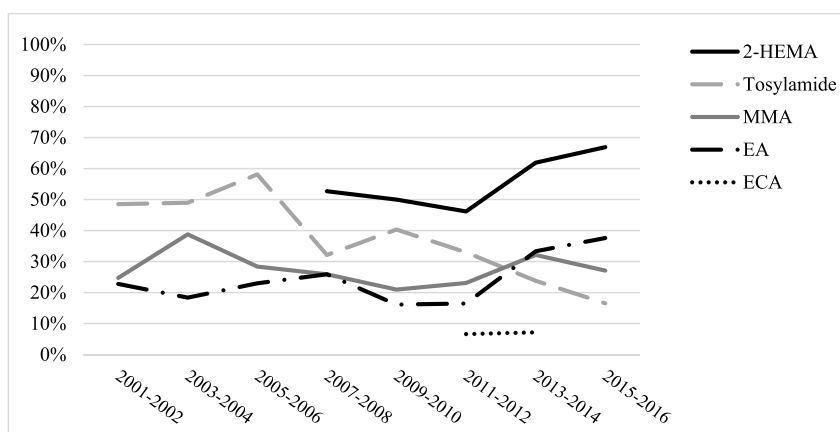
TABLE 5. Top 5 NACDG Allergens Associated With a Nail Care Product Source: Final Reaction Reading, Clinical Relevance, and Occupational Relevance

Allergen	Total*	Strength of Reaction, n (%)†				Clinical Relevance, n (%)†		
		+++	++	+	+/-?‡	Current	Past	Occupational Relevance, n (%)†
2-HEMA	273/482 (56.6)	95 (34.8)	85 (31.1)	86 (31.5)	7 (2.6)	190 (69.6)	83 (30.4)	45 (16.5)
Tosylamide	273/755 (36.2)	29 (10.6)	108 (39.6)	125 (45.8)	11 (4.0)	229 (83.9)	44 (16.1)	4 (1.5)
MMA	210/755 (27.8)	26 (12.4)	91 (43.3)	81 (38.6)	12 (5.7)	139 (66.2)	71 (33.8)	19 (9.0)
EA	190/755 (25.2)	19 (10.0)	65 (34.2)	98 (51.6)	8 (4.2)	147 (77.4)	43 (22.6)	29 (15.3)
ECA	12/175 (6.9)	1 (8.3)	1 (8.3)	9 (75.0)	1 (8.3)	9 (75.0)	3 (25.0)	0 (0.0)

*Denominator is total number of patients with positive reactions to at least 1 nail care product source. Each allergen was adjusted for the cycles during which it was tested.

†Denominator is total number of reactions linked to a nail care product source for each allergen. Strengths of reactions were defined as weak (+), strong (++), extreme (+++), macular erythema only (-/?), irritant, and negative.

‡Excludes +/-? reactions with a final interpretation of irritant or negative.



*Denominator is total number of patients with positive reactions to at least one nail care product source. Each allergen was adjusted for the cycles during which it was tested.

Figure 2. Trends in the top 5 NACDG allergens associated with a nail care product source between 2001 and 2016.

Frequency of ACD

Nail care product allergy among the general population has previously been estimated at 1% to 3%.¹⁸ Summary reports of patients referred for patch testing indicate a frequency of nail care product allergy of 1% to 8%.^{6,7,23} We found an overall frequency of 1.9% of NACDG patch-tested patients with more than 1 allergen associated with nail care products. Although this estimate comprises a relatively small percentage of overall ACD cases, nail care product allergy may have important consequences for affected individuals, particularly if allergy occurs secondary to (meth)acrylates. In fact, sensitization to (meth)acrylate-based nail care products has been reported to lead to adverse outcomes when patients are exposed to (meth)acrylates in other sources, such as dental work²⁴ and joint prostheses.²⁵

Frequency of ICD

Anecdotal, ICD is commonly associated with nail care products; certain chemicals including toluene, formaldehyde, acetone, and (meth)acrylates are recognized irritants and can cause significant damage to the nail plate and surrounding soft tissues.²⁶ Yet ICD to nail care products represented a small portion of our overall study population (0.06% of all patch tested patients). This finding is most likely due to clinical recognition of ICD to nail care products,^{26,27} obviating the need for patch test referral.

Demographics and Primary Sites of Involvement

Not surprisingly, our study population was predominantly female (>97%), similar to prior reports (Table 2). Ages ranged from 12 to 86 years, reflecting the ubiquitous usage of nail care products in all stages of life.

This study confirmed that nail care product dermatitis often affects the face (43.0%), including the eyelids (14.4%). These findings are consistent with previous studies; Lazzarini et al⁷ found the face to be affected by nail polish allergy in 86% of cases, with the periorbital region (71%), perioral region (30%), and chin (23%) most commonly involved. Özkaya and Ekinici⁶ documented a greater proportion of cases with eyelid involvement (94%), followed by the face and neck (81%). In both studies, tosylamide was the most commonly identified allergen, affecting more than 87% of patients. Subgroup analysis of our data found that individuals with tosylamide-only allergy had a significantly higher frequency of facial involvement as compared with (meth)acrylates (60.5% vs 33.2%, respectively). Conversely, hand dermatitis was significantly more common among our patients with (meth)acrylate reactions, consistent with prior reports of predominant involvement of the hands with (meth)acrylate allergy.^{11,12,17} This distribution may be explained by more occupational cases associated with (meth)acrylate nail care products (from application to clients), as well as incomplete curing in home gel nail products.¹⁶

TABLE 6. Sources of Nail Care Product Allergy

Nail Product Source	NACDG Allergens, n (%) [*]	Non-NACDG Allergens, n (%) [*]
Nail care products, NOS	145/1008 (14.4)	7/129 (5.4)
Nail polish, coatings, gels, strengtheners	276/1008 (27.4)	24/129 (18.6)
Artificial nails, extenders	460/1008 (45.6)	70/129 (54.3)
Nail adhesives	117/1008 (11.6)	24/129 (18.6)
Nail moisturizers	10/1008 (1.0)	4/129 (3.1)

*Denominator is total number of reactions linked to a nail care product source. NOS indicates not otherwise specified.

Occupational

Nail care product-related dermatitis was associated with occupation in 12.8% of our patients. Hairdressers/cosmetologists were affected most frequently (66.3% of occupationally relevant cases). A previous NACDG study found that 17.1% of occupationally related allergic reactions in cosmetologists (including hairdressers) were related to a nail source.²⁸ Nail technicians are at high risk of sensitization to (meth)acrylates given contact with allergenic monomers before curing, penetration through gloves, and airborne exposures.^{12,29,30} Protective gloves should be worn by sensitized beauticians. Double nitrile gloves provide up to 60 minutes of protection, but thicker, 4H plastic polymer gloves offer complete protection.^{13,31} However, those gloves inhibit the fine manual dexterity required by nail technicians; thus, Roche et al³² proposed the “fingerstall technique,” which involves cutting the fingers from 4H gloves and wearing these under more flexible gloves (eg, nitrile) to allow for better agility. Gatica-Ortega et al¹¹ investigated this technique in 22 beauticians with (meth)acrylate allergy and found that it was successful in 36%. In the United States, the National Institute for Occupational Safety and Health has provided guidelines for nail technicians,³³ and in the United Kingdom, the Cosmetic, Toiletry, and Perfumery Association has provided detailed techniques for minimizing sensitization from artificially enhanced nails.^{33,34}

Registered nurses and dental assistants/hygienists were the second most common occupation. These workers may become sensitized through occupational exposures,^{35,36} but our data do not include this information.

Specific Allergens

Tosylamide

Tosylamide—a thermoplastic resin imparting gloss adhesion and hardness introduced into nail polish in 1939⁹—has been a recognized cause of ACD to nail care products, often affecting the neck and eyelids.³⁷ We found a statistically significant decrease over time in reactions to tosylamide associated with nail care products. These results are consistent with the findings of Lee et al,⁹ who documented a significant decrease in the frequency of tosylamide reactions in 7408 Australian patients patch tested over an almost identical study period (2002–2017). This decrease may represent a shift by manufacturers toward “hypoallergenic” and “nontoxic” polish, in which tosylamide is replaced by polyester resins or cellulose acetate butyrate.³⁸ In addition, a decrease in tosylamide reactions may be due to increased use of other nail polish products such as long-lasting gel nail polish, which contain (meth)acrylates, and powder nails, also known as dipping powder manicure, which contain ECA.^{9,39}

2-Hydroxyethyl Methacrylate

In contrast to tosylamide, the frequency of nail care product-associated 2-HEMA reactions increased throughout the study period. 2-Hydroxyethyl methacrylate has previously been cited as the most commonly positive (meth)acrylate and is present within gel nails and Shellac gel nail polish.^{10,40–42} Rolls et al⁴⁰ suggested adding

2-HEMA to the British baseline series after finding that nearly one-third of all cases of (meth)acrylate allergy would have been missed if 2-HEMA were excluded. Drucker and Pratt⁴³ similarly found that adding 2-HEMA increased (meth)acrylate allergy detection from 73% to 91% compared with testing with EA and MMA alone. These findings reflect the overall increasing prevalence of contact allergy to (meth)acrylate nail care products in recent years, particularly in Europe,^{11,44,45} the United Kingdom,¹⁵ and now North America.

Acrylic, gel, and Shellac nails were previously applied only in nail salons; however, home gel nail polish kits are now widely available.¹⁶ Most kits come with either a UV or light-emitting diode (LED) light source, which is specific to the type of gel nail polish. Consumers using these kits are potentially at high risk of sensitization due to frequent reapplication rates and lack of proper training. For example, if a consumer uses an LED nail polish with a UV light source, there may be inadequate curing, as curing takes approximately 30 seconds for LED and 2 minutes for UV lights.¹⁶ Risk of sensitization and relapsing dermatitis may be mitigated by utilizing appropriate light sources for the recommended amount of time and avoiding cutaneous contact with uncured polish. Guidelines for home use have been developed in the United Kingdom.³⁴ A continued upsurge of allergy to 2-HEMA is expected in coming years as the use of long-lasting nail techniques becomes increasingly widespread.

Methyl Methacrylate

Methyl methacrylate, an inexpensive (meth)acrylate used in nail sculpting,⁴¹ was the next most common allergen associated with nail care product allergy in our study. Although the use of 100% MMA was banned by the US Food and Drug Administration in the 1970s, MMA can still be found illegally in certain nail salons and may be found in online products.^{46–48} Canadian regulations also restrict MMA, with an advisory warning and subsequent ban on MMA in cosmetic nail preparations issued in 2003.⁴⁹

Ethyl Acrylate

Ethyl acrylate is an acrylic monomer commonly used in the nail industry.² Our study found EA less commonly associated with nail care products as compared with 2-HEMA or MMA, similar to prior reports,^{15,50} although other studies have found that EA is more common than MMA.^{10,51} These differences may be due to variable cross-reactivity between members of the (meth)acrylate family.⁴⁵ Certain authors have proposed that 2-HEMA is the primary sensitizer, and all other acrylate reactions, including those to EA, result from structural similarities between monomers.^{45,52} The most conservative approach for affected patients involves avoidance of all (meth)acrylates.

Ethyl-2-Cyanoacrylate

Cyanoacrylates rarely cross-react with (meth)acrylates.² Therefore, nail wraps and press-on nails, which utilize cyanoacrylate-based adhesives, may be a safe alternative for some (meth)acrylate-sensitive individuals desiring long-lasting nail color. However, cyanoacrylates may lead to sensitization independently.² Dipping powders, which also

utilize ECA,³⁹ may represent a particularly high-risk source of sensitization to cyanoacrylates.¹⁷ In the current study, ECA was tested during 2 NACDG cycles, with a frequency of only 6.9% of nail sources. Positive patch test reactions to ECA were also low in a retrospective Portuguese study by Raposo et al,¹² which found a frequency of 5.7% (13/230). Interestingly in that study, all patients reacted to other (meth)acrylates. The authors discounted cross-reactivity and implicated a switch by patients from (meth)acrylate-based nail care products (due to allergy) to press-on or silk nails (eg, nail wraps) containing ECA.¹²

Other Allergens

All other allergens demonstrated frequencies of less than 2%. One patient with generalized dermatitis reacted to every member of the formaldehyde family, including imadazolidinyl urea (aq. and pet.), diazolidinyl urea (aq. and pet.), quarternium-15, DMDM hydantoin, and bronopol, all of which were attributed to a nail care product source. Another patient had a strong (++) reaction to nickel, an allergen that can be present in metal mixing balls to prevent separation of nail polish components,⁴ as well as metal extension molds for lengthening nails.^{53,54} Although uncommon, clinicians should keep in mind these additional causative allergens in nail care product dermatitis.

Sources

Artificial nails were the most common specific nail care product source, followed by nail polishes and nail adhesives. These findings align with the general pattern of allergen frequencies described previously (eg, [meth]acrylates present in artificial nails, tosylamide in polish, and cyanoacrylates in nail adhesives and dipping powders). Patients commonly use multiple nail care products, and specification of one source can be difficult. Therefore, differentiation of nail care product sources is somewhat subject to physician interpretation bias, patient recall bias, and availability of nail care product ingredient lists.

Limitations

As a retrospective study, this study is inherently limited by its design. The NACDG database does not document longitudinal outcomes; therefore, we cannot comment on whether patients improved following avoidance of responsible nail care products. Next, the 1980 Census Classified Index of Industries and Occupations includes cosmetologists, hairdressers, and nail technicians all in 1 code,²¹ so exact, occupation-specific estimates could not be obtained. Finally, names of non-NACDG allergens are not recorded (only sources of those allergens), so specific allergen names (including [meth]acrylates not on the NACDG screening series) cannot be determined. Several other allergens, including phthalates and so on, have also been reported.^{55–57} These findings underscore the importance of testing to additional series in cases of suspected nail care product allergy.

CONCLUSIONS

Although allergy to nail care products represents a minority of cases of ACD, the increasing popularity of long-lasting nail techniques will likely result in increased prevalence. In this retrospective study of a large North American cohort, patients most often presented with facial (especially those allergic to tosylamide) and/or hand dermatitis (especially those allergic to [meth]acrylates). The most common allergens associated with nail care products included tosylamide, 2-HEMA, MMA, EA, and ECA. Frequency of tosylamide allergy significantly decreased over the study period, whereas allergy to 2-HEMA and EA significantly increased. Importantly, almost one-fifth of nail care product-associated allergens would have been missed if additional allergens were not tested (beyond the NACDG screening series), underscoring the need for testing to a broad array of allergens in suspected allergy to nail care products.

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