

Occupational Contact Dermatitis in Hairdressers/Cosmetologists: Retrospective Analysis of North American Contact Dermatitis Group Data, 1994 to 2010

Erin M. Warshaw, MD, MS,* Michael Z. Wang, BS,† C.G. Toby Mathias, MD,‡ Howard I. Maibach, MD,§ Donald V. Belsito, MD,|| Kathryn A. Zug, MD,¶ James S. Taylor, MD,** Matthew J. Zirwas, MD,†† Anthony F. Fransway, MD,‡‡ Vincent A. DeLeo, MD,|| James G. Marks, Jr, MD,§§ Melanie D. Pratt, MD,||| Frances J. Storrs, MD,¶¶ Robert L. Rietschel, MD,*** Joseph F. Fowler, Jr, MD,††† and Denis Sasseville, MD‡‡‡

Background: European studies document that occupational contact dermatitis (CD) is common in hairdressers, but studies from North America are lacking.

Objectives: The objectives of this study were to estimate the prevalence of occupational CD among North American hairdressers/cosmetologists (HD/CS) and to characterize responsible allergens and irritants as well as their sources.

Methods: A cross-sectional analysis of patients patch tested by the North American Contact Dermatitis Group between 1994 and 2010 was conducted.

Results: Of 35,842 patients, 432 (1.2%) were HD/CS. Significantly, most of the HD/CS were female (89.8%) and younger than 40 years (55.6%) as compared with non-hairdressers ($P < 0.0001$). The rates for allergic and irritant CD in HD/CS were 72.7% and 37.0%, respectively. The most common body site of involvement was the hand, and this was significantly more common than in non-HD/CS ($P < 0.0001$). The most frequent currently relevant and occupationally related allergens were glyceryl thioglycolate, p-phenylenediamine, nickel sulfate, 2-hydroxyethyl methacrylate, and quaternium-15. Hair dyes, permanent wave solutions, and other hair products were common sources of allergens. The North American Contact Dermatitis Group allergen series missed at least 1 occupationally-related allergen in 26.2% of patients.

Conclusions: Contact dermatitis in North American HD/CS is common, and occupationally related allergens are those found in HD/CS products. Supplemental hairdressing/cosmetology antigen series are important in detecting all occupationally related allergens in this population.

OCCUPATIONAL SKIN diseases and disorders are the leading non-trauma-related occupational illnesses among private industries in the United States, accounting for 15.8% of the total occupational nonfatal illnesses reported in 2010 by the Bureau of Labor Statistics.¹ Among these occupational skin disorders, 90% to 95% were contact in origin.²

Various chemical compounds are used in the hairdressing and cosmetic industry, many of which are well-known causes of contact dermatitis (CD).³⁻⁸ A previous study involving 300 hairdressers showed that 41.6% of hairdressers developed skin problems within 3 years of starting their jobs,⁹ indicating a significant and early high risk of developing CD. Furthermore,

From the *Department of Dermatology, Veterans Affairs Medical Center, University of Minnesota; †University of Minnesota Medical School, Minneapolis, MN; ‡Department of Dermatology, University of Cincinnati, Cincinnati, OH; §Department of Dermatology, University of California San Francisco, San Francisco, CA; ||Department of Dermatology, Columbia University, New York, NY; ¶Dartmouth-Hitchcock Medical Center, Lebanon, NH; **Department of Dermatology, Cleveland Clinic, Cleveland, OH; ††Division of Dermatology, Department of Medicine, Ohio State University, Columbus, OH; ‡‡Private Practice, Fort Meyers, FL; §§Department of Dermatology, Pennsylvania State University, Hershey, PA; |||Division of Dermatology, University of Ottawa, Ottawa, Ontario, Canada; ¶¶Department of Dermatology, Oregon Health Science University, Portland, OR; ***Departments of Veterans Affairs Health Care System, University of Arizona, Tucson, AZ; †††University of Louisville,

Louisville, KY; and ‡‡‡Royal Victoria Hospital, McGill University, Montreal, Quebec, Canada.

Address correspondence to: Erin M. Warshaw, MD, MS, 1 Veterans Dr, 111K-Dermatology, Minneapolis, MN 55417. E-mail: erin.warshaw@va.gov.

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once a hairdresser has developed a skin contact allergy, protective measures may not be sufficiently effective, often necessitating a change in profession.¹⁰

Although there are international studies of allergy in hairdressers (Table 1), epidemiological data from the United States have been lacking. This study sought to evaluate the prevalence of occupational CD in North American hairdressers/cosmetologists (HD/CS) using the last 17 years of data collected by the North American Contact Dermatitis Group (NACDG). In addition, we sought to evaluate responsible allergens, irritants, and their sources and to estimate the diagnostic effectiveness of NACDG standard series in patients who are HD/CS.

METHODS

The NACDG Database

This study was approved by the Minneapolis Veterans Affairs Medical Center Human Studies Subcommittee. Between July 1, 1994, and December 31, 2010, the NACDG patch test standard series consisted of 50 to 70 allergens. The patch testing methods of NACDG and the procedures for determination of allergic reaction relevance and final diagnoses were previously described.¹¹ Data collected in the database included demographic information (age, sex, race, and occupation), sites of dermatitis (up to 3 sites), diagnoses (up to 3 diagnoses), and patch testing results of specific antigens, which included reactivity strength, clinical relevance (definite, possible, probable, and past), occupational relevance (yes, no), and the source of exposure. Information for sources of exposure was not recorded between July 1994 and June 1996. Between July 1996 and December 2000, sources were recorded with single-digit codes with less detail and, hence, excluded from the data on sources presented herein. From January 2001 to December 2010, detailed triple-digit source codes were collected. Clinically relevant non-NACDG standard allergens, occupational relevance, and sources were recorded starting in January 2001.

Study Population

The study population was composed of HD/CS. From July 1994 to June 1996, occupations were manually recorded and expressed as text. Starting in July 1996, the NACDG adopted a standard coding system based on the US Census Bureau definitions, which includes hairdressers and cosmetologists in the same code.¹² Barbers were also included because of the similarity of their work environments.¹³ Because different occupation codes were used during different periods, methods differ by data cycle. From July 1994 to June 1996, patients with occupations of "hairdresser," "hair stylist," "beautician," and "barber" were categorized as HD/CS. For data from July 1996 to December 2010, 3-digit standard occupational codes from the US Census Bureau corresponding to "barber" and "hairdresser/cosmetologist" were defined as HD/CS subjects.¹² Non-HD/CS were defined as individuals not coded as hairdresser/cosmetologist or barbers, and this included persons in

all other occupations as well as unemployed persons, students, and home makers but excluded those with missing occupation codes.

Data Analysis

At a central location, all data were checked for quality assurance and then manually entered into a computerized database (Access 2007; Microsoft Corp, Redmond, Wash). Data from HD/CS were compared with those from non-HD/CS with Pearson χ^2 test (Fisher exact test, 2 tailed, when appropriate) and calculation of relative risk (RR) with confidence intervals (CIs) using SAS software (version 9.2, Statistical Analysis System; SAS Institute, Inc, Cary, NC). A *P* value less than or equal to 0.05 was considered statistically significant for all analyses. Given the exploratory nature of this analysis, no adjustments were made for multiple comparisons.

RESULTS

Demographics

Between July 1, 1994, and December 31, 2010, 35,872 patients were patch tested by the NACDG; 432 (1.2%) were HD/CS (Fig. 1). Individuals with no recorded occupation were excluded from the remaining analyses (7.1%, *n* = 2549).

As shown in Table 2, characteristics that were statistically significantly higher in HD/CS included female sex (RR, 1.40; 95% CI, 1.35–1.44), occupational dermatitis (RR, 4.20), and younger age (RR, 1.67). Of the top 10 sites of dermatitis, hand involvement was significantly higher in HD/CS as compared with non-HD/CS (RR, 2.49), whereas scattered generalized distribution (RR, 0.45), leg (RR, 0.47), foot (RR, 0.55), and/or trunk (RR, 0.39) involvement were significantly lower in HD/CS. The most frequent final diagnoses were allergic CD (72.7%), irritant CD (37%), and atopic dermatitis (11.6%; Table 3).

Patch Test Results

As shown in the Figure 1, 63.9% (276/432) of HD/CS had at least 1 currently relevant NACDG allergic reaction. Of these, 67.8% (*n* = 187) had at least 1 currently relevant and occupationally related NACDG allergic reaction. As summarized in Table 4, for the entire study period (1994–2010), the top 5 most frequent clinically relevant and occupationally related allergens included glyceryl thioglycolate (54.0%), *p*-phenylenediamine (53.0%), nickel sulfate (30.1%), 2-hydroxyethyl methacrylate (HEMA; 26.3%), and quaternium-15 (20.1%). For the early period (1994–2004), prevalence rates to glycerol thioglycolate and quaternium-15 were higher than in the later period (2005–2010), whereas nickel was lower.

North American Contact Dermatitis Group Allergen Sources

The sources of NACDG allergens in HD/CS with clinically relevant and occupationally related allergic reactions are in Table 5.

TABLE 1. Publications of Patch Testing in Hairdressers

Study (Country)	Publication Year	Patch-Tested Population	No. Hairdressers	Top 5 Allergens (Percentage in Hairdressers)
Present study (North America)	Current	35,872	432	1. Glyceryl thioglycolate (54.0) 2. p-Phenylenediamine (53.0) 3. Nickel sulfate (30.1) 4. HEMA (26.3) 5. Quaternium-15 (20.1)
Information Network of Departments of Dermatology ¹⁴ (Austria, Germany, and Switzerland)	2003	2101	884	1. Ammonium persulfate (26.1) 2. p-Toluenediamine (24.8) 3. p-Phenylenediamine (22.0) 4. Glyceryl thioglycolate (18.1) 5. Fragrance mix I (9.4)
European Environmental and Contact Dermatitis Research Group ¹⁵ (Germany, Ireland, Spain, Belgium, France, Finland, Denmark, United Kingdom)	1993	913	809	1. Glyceryl thioglycolate (19) 2. p-Phenylenediamine (15) 3. Ammonium persulfate (8) 3. p-Toluenediamine (8) 5. o-Nitro-p-phenylenediamine (4) 5. p-Aminodiphenylamine hydrochloride (4)
Information Network of Departments of Dermatology ¹⁶ (Europe)	2007	37,929	480	1. Ammonium persulfate (21.7) 2. p-Toluenediamine (19.6) 3. p-Phenylenediamine (18.1) 4. Glyceryl thioglycolate (9.8) 5. Fragrance mix I (7.6)
Conde-Salazar et al ¹⁷ (Spain)	1995	379	379	1. p-Phenylenediamine (45.9) 2. Nickel sulfate (41.4) 3. Disperse orange 3 (32.7) 4. p-Aminoazobenzene (31.9) 5. Thioglycolic acid (15.3)
Gruppo Italiano Ricerca Dermatiti da Contatto e Ambientali ¹⁸ (Italy)	1992	302	302	1. p-Phenylenediamine (16.6) 2. p-Toluenediamine (13.2) 3. Glyceryl thioglycolate (11.3) 3. Ammonium persulfate (11.3) 5. p-Aminodiphenylamine (10.6)
Valks et al ⁹ (Spain)	2005	300	300	1. p-Phenylenediamine (54.0) 2. p-Aminobenzene (40.7) 3. Nickel sulfate (37.0) 4. Disperse orange (17.0) 5. p-Toluenediamine (15.33)
Katsarou et al ¹⁹ (Greece)	1995	106	106	1. Nickel sulfate (42.4) 2. p-Phenylenediamine (30.2) 3. Ammonium persulfate (17.9) 4. Ammonium thioglycolate (11.3) 5. p-Toluenediamine (10.3)
Van Der Walle et al ²⁰ (Netherlands)	1994	103	103	1. Glyceryl thioglycolate (57.3) 2. Nickel sulfate (36.9) 3. Ammonium persulfate (35.9) 4. Fragrance mix I (7.8) 5. Methylchloroisothiazolinone/methylisothiazolinone (6.8)
Guo et al ²¹ (Taiwan)	1994	98	98	1. Nickel sulfate (22.4) 2. Captan (6.1) 3. Fragrance mix I (5.1)

(continued next page)

TABLE 1. (Continued)

Study (Country)	Publication Year	Patch-Tested Population	No. Hairdressers	Top 5 Allergens (Percentage in Hairdressers)
Lynde et al ²² (Canada)	1982	66	66	3. Methylchloroisothiazolinone/methylisothiazolinone (5.1) 5. Formaldehyde (3.1) 5. p-Phenylenediamine (3.1) 1. p-Phenylenediamine (45.5) 2. Nickel sulfate (27.3) 3. Glyceryl thioglycolate (9.1) 4. p-Toluenediamine (7.6) 5. Balsam of Peru (6.1)
Park et al ²³ (Korea)	2006	61	61	1. Nickel sulfate (37.7) 2. Cobalt chloride (34.4) 3. p-Phenylenediamine (21.3) 4. Thimerosal (11.5) 5. Potassium dichromate (9.8)
Holness et al ²⁴ (Canada)	1990	1440	55	1. p-Phenylenediamine (51) 2. Glyceryl thioglycolate (23.5) 3. Nickel sulfate (17.0) 4. Ammonium persulfate (14.7) 5. Formaldehyde (9.4) 5. p-Toluenediamine (9.4)
Leino et al ²⁵ (Scandinavia)	1998	54	54	1. Nickel sulfate (35.2) 2. Cobalt chloride (13.0) 3. Neomycin sulfate (7.4) 4. Balsam of Peru (5.6) 5. p-Phenylenediamine (3.7) 5. Methylchloroisothiazolinone/methylisothiazolinone (3.7)

Publications in English are with 20 or more hairdressers.

Hair dyes (38.5%), permanent wave solutions (29.4%), personal care products (21.4%), hair care products (16.6%), gloves (10.2%), and moisturizers (10.2%) were the most common sources identified.

Non-NACDG Allergen Sources

The reaction rates for allergens not on the standard NACDG standard screening series and their sources are in Table 6. The most common sources of non-NACDG allergens in HD/CS were hair dyes (9.4%), hair care products (4.9%), artificial nails (3.9%), permanent wave solutions (2.9%), personal care products (1.9%), and jewelry (1.9%).

Irritant Sources

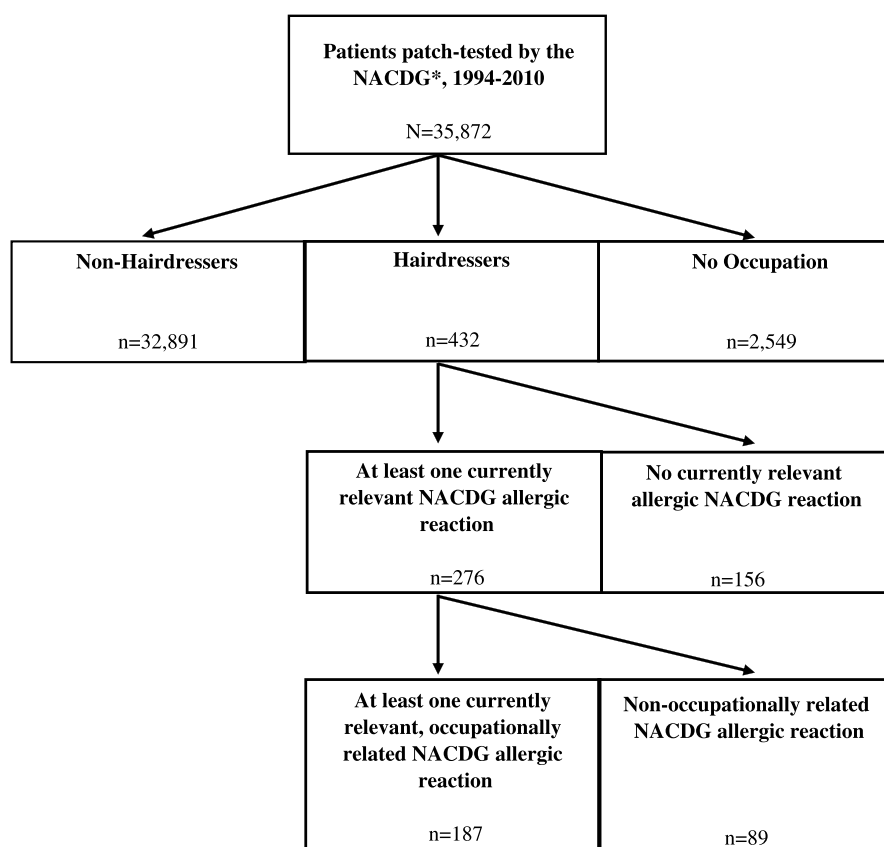
There were 122 relevant irritants reported in HD/CS. Of these, 98 (80.3%) were occupationally related. Table 7 presents sources of relevant irritants in NACDG patch-tested HD/CS and proportions of those which were occupationally related. The most common irritant sources were shampoos, hair care products, non-skin soaps, nail adhesives, and skin cleansers.

Detection Rate of NACDG Allergen Series

Of the 309 HD/CS patch tested from 2001 to 2010, 99 (32%) had at least 1 clinically relevant, non-NACDG allergen; 81 patients (26.2%) had at least 1 occupationally related non-NACDG allergen.

DISCUSSION

This study is the first large epidemiological evaluation of patch-tested HD/CS in North America and documents several key findings. First, approximately two thirds of HD/CS had at least 1 currently relevant allergic reaction, and two thirds of those allergens were related to their occupation. Reaction rates to specific allergens were similar to studies from other countries.^{9,14–25} Second, 26.2% of patch-tested HD/CS had at least 1 clinically relevant and occupationally related allergic reaction to a non-NACDG allergen, underscoring the importance of testing with additional allergen series and patient products in this population. Third, ICD was diagnosed in one third of HD/CS; shampoo and hair products were the most identified occupational irritant sources. These findings provide important information for



*NACDG = North American Contact Dermatitis Group

Figure 1. Study population subgroups.

clinicians on the profile of CD among HD/CS referred for patch testing in North America.

Demographics

Hairdressers/cosmetologists were more likely to be female and younger than 40 years than non-HD/CS. This finding is not surprising and is generally reflective of the US work force; in 2010, the US Bureau of Labor and Statistics documented that 91.9% of HD/CS were female.^{26,27} We found that the frequency of occupational skin disease was higher in HD/CS than in non-HD/CS. This is also somewhat expected and consistent with the widely held acceptance that HD/CS are at high risk for developing CD.^{4-8,15,18,28,29} In Europe, the highest rate of occupational skin disease in HD/CS was reported in United Kingdom, with annual incidence of 23.9 per 100,000 workers.³⁰

Although hands were the most commonly affected site for both HD/CS and non-HD/CS, the RR of hand involvement was 2.5 times higher in HD/CS (72.5%) as compared with non-HD/CS (29.1%). This finding is also consistent with previous reports, which found high rates (80.2%¹⁸ and 93.0%¹⁶) of hand dermatitis in patch-tested HD/CS. Previous studies of HD/CS have

estimated the lifetime risk of hand dermatitis to be 29.1%,³¹ 37.6%,³² and 44.5%.³³

Allergens

The top 3 currently relevant and occupationally related allergens in HD/CS were glyceryl thioglycolate, p-phenylenediamine, and nickel sulfate. These common allergens are universally high in studies of HD/CS (Table 1) and confirm the allergenicity of these compounds in the workplace, usually from permanent hair wave solutions, hair dye, and tool/hair ornament sources, respectively. The rate of allergic reactions to glyceryl thioglycolate decreased by approximately 50% from the earlier period (1994–2004) as compared with the later period (2005–2010); this corresponds with the decreased popularity of permanent wave hair styles.

2-Hydroxyethyl methacrylate, one of the most common acrylate sensitizers in current artificial nail products,³⁴⁻³⁷ was the fourth most common occupationally related allergen in our study population. The high prevalence of reactions to acrylates (HEMA, ethyl acrylate, and methyl methacrylate) in our study could be due to differences in either study design or HD/CS tasks in different regions of the world. Our study design was based on the US

TABLE 2. Demographics of Hairdressers/Cosmetologists and Non-HD/CS Referred for Patch Testing

Demographic	Hairdressers (n* = 432), n (%)	Non-hairdressers (n* = 32,891), n (%)	RR (95% CI), P
Male†	44 (10.2)	11,732 (35.7)	0.29 (0.22–0.38), <0.0001
Occupational†	270 (62.5)	4900 (14.9)	4.20 (3.88–4.53), <0.0001
Atopic‡	181 (41.9)	12,811 (38.9)	1.07 (0.96–1.20), 0.2119
Hay Fever	115 (26.6)	8750 (26.6)	1.00 (0.85–1.17), 0.9935
Atopic dermatitis†	81 (18.8)	6119 (18.6)	1.01 (0.83–1.23), 0.9382
Asthma	67 (15.5)	4405 (13.4)	1.16 (0.93–1.45), 0.1998
Age >40 y†	192 (44.4)	21,970 (66.8)	0.67 (0.60–0.74), <0.0001
Sites§			
Hand†	313 (72.5)	9562 (29.1)	2.49 (2.35–2.65), <0.0001
Face†	82 (19.0)	6873 (20.9)	0.91 (0.75–1.11), 0.3306
Arm	80 (18.5)	5039 (15.3)	1.21 (0.99–1.48), 0.0670
Scattered generalized	39 (9.0)	6671 (20.3)	0.45 (0.33–0.60), <0.0001
Neck	36 (8.3)	2760 (8.4)	0.99 (0.72–1.36), 0.9655
Eyelids	27 (6.3)	2858 (8.7)	0.72 (0.50–1.04), 0.0733
Leg†	22 (5.1)	3529 (10.7)	0.47 (0.32–0.71), 0.0002
Trunk	19 (4.4)	3716 (11.3)	0.39 (0.25–0.60), <0.0001
Foot	18 (4.2)	2494 (7.6)	0.55 (0.35–0.87), 0.0075
Scalp	13 (3.0)	1335 (4.1)	0.74 (0.43–1.27), 0.2713
Other	30 (6.9)	5366 (16.3)	

*Number of patients in the specified group.

†MOAHLFA index.

‡Atopic dermatitis, asthma, or hay fever.

§Up to 3 anatomic sites were coded, thus for a total of more than 432.

Census Bureau codes, which combine cosmetologists and hairdressers into 1 code. Cosmetologists are defined as individuals who beautify the skin, nails, and/or hair.³⁸ Nail technicians, who are occupationally exposed to acrylates in artificial nails, are coded as cosmetologists. This could explain the high rate of acrylate allergy in “hairdressers/cosmetologists” in our study as compared with other studies. 2-Hydroxyethyl methacrylate is not a necessary screening chemical for a hairdresser series, but it is an important screening allergen for nail technicians and their clients.

In our study, quaternium-15 was the fifth most common occupationally related allergen in HD/CS. This differs from other studies of hairdressers (Table 1) that found reaction rates of 0.9%^{16,19} and 1.5%.²² These differences could be explained by 4 potential factors: study design, allergen concentration, regional sensitivity rates, or study period. As described above, our study design included cosmetologists who could be exposed to quaternium-15 in makeup, lotions, and other cosmetics. Our study design also evaluated a large screening tray, rather than a specific hairdressing allergen series, as most other hairdresser studies; the use of a specific hairdressing tray would artificially inflate the relative ranking of specific hairdressing allergens such as p-toluenediamine. Most European groups test quaternium-15 at a 1% concentration as compared with the 2% used by the NACDG. This difference in antigen concentration could lead to considerable variations in patch testing reaction rates.³⁹ De Groot and Coenraads⁴⁰ reviewed 25 years of patch testing experience with quaternium-15 on the European standard series and demonstrated consistently lower reaction rates (0.4%–3.3%) as

compared with the United States (5.1%–10.3%).^{3,11,41–48} Concomitant formaldehyde allergy is also more common in the United States.^{41,49} Finally, our study shows that the reaction rate of quaternium-15 has decreased in recent years (Table 4).

Detection rate of NACDG Allergen Series

From 2001 to 2010, 32% of HD/CS had at least 1 clinically relevant non-NACDG allergen, and 26.2% had at least 1 clinically relevant and occupationally related non-NACDG allergen. This suggests that if HD/CS were patch tested with only the NACDG standard series, at least 1 non-NACDG occupational allergen would have been missed in one fourth of the patients. Thus, it is recommended that additional hairdressing allergens not on the

TABLE 3. Final Diagnosis of Hairdressers/Cosmetologists Referred for Patch Testing

Diagnosis	Frequency (n = 432), n (%)
Allergic CD	314 (72.7)
Irritant CD	160 (37.0)
Atopic dermatitis	50 (11.6)
Other dermatitis	27 (6.3)
Other dermatoses	23 (5.3)
Psoriasis	11 (2.5)
Nummular dermatitis	8 (1.9)
Contact urticaria	5 (1.2)
Other	11 (2.5)

Up to 3 final diagnoses were coded, thus for a total of more than 432.

TABLE 4. Reaction Rates of NACDG Allergens in Hairdressers/Cosmetologists *

Rank	Allergen	1994-2010		1994-2004		2005-2010	
		Currently Relevant and Occupation-Related		Currently Relevant and Occupation-Related		Currently Relevant and Occupation-Related	
		Allergic Reaction, n†/n‡ (%)	Currently Relevant Allergic Reaction, n†/n‡ (%)	Allergic Reaction, n†/n‡ (%)	Currently Relevant Allergic Reaction, n†/n‡ (%)	Allergic Reaction, n†/n‡ (%)	Currently Relevant Allergic Reaction, n†/n‡ (%)
1	Glyceryl thioglycolate 1% pet	101/187 (54.0)	115/276 (41.7)	78/119 (65.5)	89/169 (52.7)	23/68 (33.8)	26/107 (24.3)
2	p-Phenylenediamine 1% pet	97/183 (53.0)	108/271 (39.9)	64/116 (55.2)	69/165 (41.8)	33/67 (49.3)	39/106 (36.8)
3	Nickel sulfate 2.5% pet	55/183 (30.1)	87/270 (32.2)	29/116 (25)	44/164 (26.8)	26/67 (38.8)	43/106 (40.6)
4	HEMA 2.0% pet	15/57 (26.3)	16/88 (18.2)	0/0 (NA)	0/0 (NA)	15/57 (26.3)	16/88 (18.2)
5	Quaternium-15 2% pet	37/184 (20.1)	53/272 (19.5)	32/116 (27.6)	44/165 (26.7)	5/68 (7.4)	9/107 (8.4)
6	Formaldehyde 1% aq	27/184 (14.7)	41/272 (15.1)	20/116 (17.2)	30/165 (18.2)	7/68 (10.3)	11/107 (10.3)
7	Fragrance mix I 8% pet	26/187 (13.9)	41/276 (14.9)	15/119 (12.6)	23/169 (13.6)	11/68 (16.2)	18/107 (16.8)
8	Sodium gold thiosulfate 0.5% pet	15/108 (13.9)	22/150 (14.7)	15/108 (13.9)	22/150 (14.7)	0/0 (NA)	0/0 (NA)
9	Cobalt chloride 1% pet	24/187 (12.8)	30/275 (10.9)	14/119 (11.8)	20/168 (11.9)	10/68 (14.7)	10/107 (9.3)
10	Ethyl acrylate 0.1% pet	17/187 (9.1)	20/276 (7.2)	10/119 (8.4)	13/169 (7.7)	7/68 (10.3)	7/107 (6.5)
11	Dimethylaminopropylamine 1.0% aq	2/24 (8.3)	3/42 (7.1)	0/0 (NA)	0/0 (NA)	2/24 (8.3)	3/42 (7.1)
12	Thiuram mix 1% pet	15/184 (8.2)	19/272 (7.0)	10/116 (8.6)	14/165 (8.5)	5/68 (7.4)	5/107 (4.7)
13	Bacitracin 20% pet	14/187 (7.5)	29/276 (10.5)	10/119 (8.4)	20/169 (11.8)	4/68 (5.9)	9/107 (8.4)
14	Neomycin sulfate 20% pet	13/183 (7.1)	31/271 (11.4)	9/116 (7.8)	21/165 (12.7)	4/67 (6)	10/106 (9.4)
15	Methyldibromo glutaronitrile/phenoxethanol 2.0% pet	11/161 (6.8)	18/234 (7.7)	9/93 (9.7)	12/127 (9.4)	2/68 (2.9)	6/107 (5.6)
16	Glutaraldehyde 0.5% pet	1/15 (6.7)	2/23 (8.7)	1/15 (6.7)	2/23 (8.7)	0/0 (NA)	0/0 (NA)
17	Carba mix 3% pet	11/184 (6.0)	17/272 (6.3)	5/116 (4.3)	10/165 (6.1)	6/68 (8.8)	7/107 (6.5)
18	Methylchloroisothiazolinone/methylisothiazolinone 100 ppm aq	11/187 (5.9)	14/276 (5.1)	7/119 (5.9)	10/169 (5.9)	4/68 (5.9)	4/107 (3.7)
19	Cocamide DEA 0.5% pet	7/131 (5.3)	10/194 (5.2)	5/63 (7.9)	5/87 (5.7)	2/68 (2.9)	5/107 (4.7)
20	Propolis 10.0% pet	3/57 (5.3)	5/88 (5.7)	0/0 (NA)	0/0 (NA)	3/57 (5.3)	5/88 (5.7)
21	Methyldibromo glutaronitrile 0.4% pet	3/60 (5.0)	5/82 (6.1)	3/60 (5)	5/82 (6.1)	0/0 (NA)	0/0 (NA)
22	Balsam of Peru 25% pet	9/184 (4.9)	21/272 (7.7)	5/116 (4.3)	11/165 (6.7)	4/68 (5.9)	10/107 (9.3)
23	Methyl methacrylate 2% pet	9/187 (4.8)	11/276 (4.0)	6/119 (5)	8/169 (4.7)	3/68 (4.4)	3/107 (2.8)
24	Tosylamide formaldehyde resin 10% pet	8/187 (4.3)	14/276 (5.1)	5/119 (4.2)	11/169 (6.5)	3/68 (4.4)	3/107 (2.8)

(continued next page)

TABLE 4. (Continued)

Rank	Allergen	1994-2010		1994-2004		2005-2010	
		Currently Relevant and Occupation-Related Allergic Reaction, n†/n‡ (%)	Currently Relevant Allergic Reaction, n†/n‡ (%)	Currently Relevant and Occupation-Related Allergic Reaction, n†/n‡ (%)	Currently Relevant Allergic Reaction, n†/n‡ (%)	Currently Relevant and Occupation-Related Allergic Reaction, n†/n‡ (%)	Currently Relevant Allergic Reaction, n†/n‡ (%)
25	2-Bromo-2-nitropropane-1,3-diol 0.5% pet	8/187 (4.3)	13/276 (4.7)	5/119 (4.2)	7/169 (4.1)	3/68 (4.4)	6/107 (5.6)
26	Diazolidinyl urea 1% pet	8/187 (4.3)	11/276 (4.0)	6/119 (5)	7/169 (4.1)	2/68 (2.9)	4/107 (3.7)
27	DMDM hydantoin 1% pet	8/187 (4.3)	9/276 (3.3)	5/119 (4.2)	6/169 (3.6)	3/68 (4.4)	3/107 (2.8)
28	Oleamidopropyl dimethylamine 0.1% aq	1/24 (4.2)	2/42 (4.8)	0/0 (NA)	0/0 (NA)	1/24 (4.2)	2/42 (4.8)
29	Disperse blue mix (124/106) 1.0% pet	1/24 (4.2)	1/42 (2.4)	0/0 (NA)	0/0 (NA)	1/24 (4.2)	1/42 (2.4)
30	Methyldibromo glutaronitrile/ phenoxyethanol 1.0% pet	1/25 (4.0)	1/41 (2.4)	1/25 (4)	1/41 (2.4)	0/0 (NA)	0/0 (NA)
31	Cocamidopropyl betaine 1% aq	5/131 (3.8)	6/194 (3.1)	2/63 (3.2)	3/87 (3.4)	3/68 (4.4)	3/107 (2.8)
32	Imidazolidinyl urea 2% aq	6/163 (3.7)	10/234 (4.3)	3/119 (2.5)	5/169 (3)	3/44 (6.8)	5/65 (7.7)
33	Fragrance mix II 14.0% pet	2/57 (3.5)	3/88 (3.4)	0/0 (NA)	0/0 (NA)	2/57 (3.5)	3/88 (3.4)
34	Benzalkonium chloride 0.1% aq	1/30 (3.3)	2/42 (4.8)	1/30 (3.3)	2/42 (4.8)	0/0 (NA)	0/0 (NA)
35	Imidazolidinyl urea 2% pet	6/187 (3.2)	7/276 (2.5)	5/119 (4.2)	5/169 (3)	1/68 (1.5)	2/107 (1.9)
36	Ethyleneurea melamine formaldehyde 5% pet	4/130 (3.1)	4/188 (2.1)	4/119 (3.4)	4/169 (2.4)	0/11 (0)	0/19 (0)
37	Diazolidinyl urea 1% aq	5/163 (3.1)	6/234 (2.6)	3/119 (2.5)	4/169 (2.4)	2/44 (4.5)	2/65 (3.1)

*Allergens with occupationally related positive reaction of greater than 3% in the combined study period.

†Number of positive reactions.

‡Total number of patients tested to allergen in specified group.

NA, not applicable.

TABLE 5. Sources of Clinically Relevant and Occupationally Related Allergens in Hairdressers/Cosmetologists, (2001–2010)*

Source	Frequency (n = 187), n (%)
Hair dyes	72 (38.5)
Permanent wave solutions	55 (29.4)
Cosmetics, beauty preparations, skin and health care products (type not specified)	40 (21.4)
Hair care products (type not specified)	31 (16.6)
Gloves	19 (10.2)
Moisturizers, lotions, creams	19 (10.2)
Artificial nails	18 (9.6)
Jewelry	15 (8.0)
Shampoos	15 (8.0)
Antibiotics	14 (7.5)
Equipment, instruments, miscellaneous supplies (type not specified)	13 (7.0)
Cosmetics (type not specified)	12 (6.4)
Tools	8 (4.3)
Nail adhesives	6 (3.2)
Nail polish	5 (2.7)
Personal grooming devices, applicators	5 (2.7)
Hair sprays and gels	4 (2.1)
Acrylic resins (raw material)	3 (1.6)
Nail care products (type not specified)	3 (1.6)
Shirts, pants, blouses, dresses, skirts	3 (1.6)
Sterilizing solutions	3 (1.6)

*Occupationally related sources with reaction rate of greater than 1.5%.

NACDG tray be tested. Lists of suggested hairdressing allergens have been previously published.^{3,50}

Sources

Common sources of NACDG and non-NACDG allergens identified here were mainly composed of hairdressing and cosmetic products including hair dyes, hair care products, permanent wave solutions, personal care products, artificial nails, and moisturizers as well as gloves. These sources were expected because of their presence in hairdressing and cosmetic industries.

Identification of gloves as a common NACDG allergen source can be explained by their use in protection against hairdressing chemicals. Guerra et al¹⁸ reported that 72.7% of Italian hairdressers use glove protection during hair dyeing, 48.9% during washing of dyed hair, and 32.7% during permanent wave application.

Irritants

In this study, 37% of patch-tested HD/CS were ultimately diagnosed with irritant CD. This figure resembles that reported by the German Group, Information Network of Department of Dermatology, which recorded irritant CD as the final diagnosis in 36.8% of their cohort of patch-tested hairdressers.¹⁴ Although

this percentage is not insignificant, it almost certainly is an underestimation because of the referral bias and/or undercoding of irritants. Of the irritant sources identified in this study, shampoo, hair products, and non-skin cleansers (possibly salon workstation cleansers) were most commonly identified. Water, a notorious irritant in wet work exposures,^{51–54} was not specifically coded.

LIMITATIONS

This study has several limitations. First, as a cross-sectional study, causal relationships cannot be determined. Second, many HD/CD work solo or part time without health care benefits; these individuals likely would not be able to afford specialized testing. Third, it is possible that our study population represents HD/CS who have relatively long-standing, recalcitrant hand dermatitis; thus, apprentices with hand dermatitis may not be included in this population. Data on duration of dermatitis and length of occupation are not collected by our group. Fourth, our results of

TABLE 6. Sources of Non-NACDG Allergens in Hairdressers/Cosmetologists (2001–2010; n† = 309)

Source	Frequency, n*/n† (%)	Occupation Related, n*/n‡ (%)
Hair dyes	29/309 (9.4)	28/29 (96.6)
Hair care products	15/309 (4.9)	13/15 (86.7)
Artificial nails	12/309 (3.9)	12/12 (100.0)
Permanent wave solutions	9/309 (2.9)	9/9 (100.0)
Cosmetics, beauty preparations, skin and health care products	6/309 (1.9)	2/6 (33.3)
Jewelry	6/309 (1.9)	0/6 (0.0)
Nail care products	2/309 (0.6)	2/2 (100.0)
Nail adhesives	2/309 (0.6)	2/2 (100.0)
Perfumes and fragrances	2/309 (0.6)	2/2 (100.0)
Cosmetics	2/309 (0.6)	1/2 (50.0)
Acrylic resins (raw material)	1/309 (0.3)	1/1 (100.0)
Sterilizing solutions	1/309 (0.3)	1/1 (100.0)
Hair sprays and gels	1/309 (0.3)	1/1 (100.0)
Moisturizers, lotions, creams	1/309 (0.3)	1/1 (100.0)
Waterless hand soaps	1/309 (0.3)	1/1 (100.0)
Adhesives, glues, bonding agents	1/309 (0.3)	1/1 (100.0)
Nail polish	1/309 (0.3)	1/1 (100.0)
Dental prosthesis	1/309 (0.3)	1/1 (100.0)
Gloves	1/309 (0.3)	1/1 (100.0)
Bakery products, candy, snack foods	1/309 (0.3)	0/1 (0.0)
Medications, topical	1/309 (0.3)	0/1 (0.0)
Miscellaneous health aids	1/309 (0.3)	0/1 (0.0)
Sealants and bonders	1/309 (0.3)	0/1 (0.0)
Unknown	1/309 (0.3)	1/1 (100.0)
Total	99/309 (32.0)	81/99 (81.8)

*Number of positive reactions.

†Total number of hairdressers.

‡Total number of patients with non-NACDG standard allergens with specified source.

TABLE 7. Relevant Irritant Sources in Hairdressers/Cosmetologists (2001–2010)*

Source	Irritant Reactions (n† = 432), n (%)‡	Occupationally Related, n‡/n§ (%)
Shampoos	36 (8.3)	36/36 (100.0)
Hair care products (type not specified)	34 (7.9)	30/34 (88.2)
Soaps, detergents, cleansers, disinfectants, laundry (nonskin use)	12 (2.8)	10/12 (83.3)
Nail adhesives	4 (0.9)	4/4 (100.0)
Soaps and cleansers (skin use)	4 (0.9)	3/4 (75.0)
Hair dyes	4 (0.9)	2/4 (50.0)
Artificial nails	3 (0.7)	3/3 (100.0)
Liquid, lotion and bar soaps, and cleaners	3 (0.7)	3/3 (100.0)
Tap water	3 (0.7)	2/3 (66.7)
Ketones	1 (0.2)	1/1 (100.0)
Alcohol	1 (0.2)	1/1 (100.0)
Nail polish	1 (0.2)	1/1 (100.0)
Other	11 (0.5)	1/2 (50.0)
Total	122 (28.2)	98/122 (80.3)

*Sources with 1 or more occupationally related irritant.

†Total number of hairdressers patch tested (432).

‡Number of irritant reactions.

§Total number of patients with irritant reactions with specified source.

||Percent of irritant reactions.

HD/CS are not directly comparable to studies involving only HDs. Finally, these results from a tertiary referral population of HD/CS with a suspected contact allergy may not be generalizable to a general HD/CS population, although clearly, patch testing HD/CS with suspected contact allergy yields a high percentage of occupationally relevant allergens.

SUMMARY

This large epidemiological evaluation of patch-tested HD/CS in North America found that two thirds had at least 1 currently relevant allergic reaction and two thirds of those allergens were occupationally related. Responsible allergens were not unexpected and included glyceryl thioglycolate, p-phenylenediamine, and nickel. Hair dyes, permanent wave solutions, artificial nails, personal care products, hair care products, gloves, and moisturizers were common sources of responsible allergens. Approximately one fourth of patch-tested HD/CS had at least 1 clinically relevant and occupationally related allergic reaction to a non-NACDG allergen, underscoring the importance of testing with additional allergen series in this population. One third of HD/CS were diagnosed with ICD; shampoo and hair products were common culprits.

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