

Trends in Patch Testing With the Mayo Clinic Standard Series, 2011–2015

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Background: Patch testing to a standard (baseline) series of allergens is the screening tool used to identify culprit allergens in patients with contact dermatitis. The allergens and concentrations used in a standard series are constantly evolving to be most relevant to the patients being patch tested.

Objective: The aim of this study was to analyze the 2011–2015 patch test results of the Mayo Clinic standard series.

Methods: We retrospectively reviewed patch test reactions of standard series allergens from 2011 through 2015 and compared these results with the 2011–2012 and 2013–2014 North American Contact Dermatitis Group (NACDG) reports.

Conclusions: Of 2582 patients included, 1566 (60.7%) had at least 1 positive reaction, and 516 (20.0%) had at least 1 irritant reaction. The 15 allergens with the highest reaction rates (from highest to lowest) were nickel sulfate hexahydrate, methylisothiazolinone, *Myroxylon pereirae* resin, neomycin sulfate, cobalt (II) chloride hexahydrate, benzalkonium chloride, fragrance mix I, potassium dichromate, bacitracin, methylchloroisothiazolinone/methylisothiazolinone, carba mix, formaldehyde, *p*-phenylenediamine, quaternium-15, and methyldibromo glutaronitrile. Twelve (80%) of these allergens were also in the top 15 of the most recent NACDG report; the 3 allergens not in the NACDG top 15 allergens were potassium dichromate, benzalkonium chloride, and methyldibromo glutaronitrile (the latter 2 allergens are not included in their series).

A standard (also termed *baseline*) series is a series of allergens that are most commonly associated with allergic contact dermatitis in a population. The standard series is constantly in evolution as newly relevant allergens are identified and others become less relevant. We have previously published our 5-year experiences with the standard series^{1–3}; these reports inform and reflect trends in relevant common allergens that are associated with allergic contact dermatitis.

We present a 5-year update and analysis of standard series patch test results from patients seen at 3 group practices within our institution. We compared those results with the patch test results from 2011 through 2012⁴ and 2013 through 2014⁵ published by the North American Contact Dermatitis Group (NACDG). We also present

changes to the Mayo Clinic standard series and the reasons for the addition or deletion of particular antigens.

METHODS

Patients

After approval was obtained from our institutional review board, we retrospectively searched our electronic patch testing database for patient patch test results from 3 group practices of the Contact Dermatitis Group within our institution from January 1, 2011, through December 31, 2015. Patients who did not provide authorization for the use of their medical data for research were excluded from the analysis.

Interpretation of Patch Test Results

Patch testing was performed in accordance with the NACDG standardized technique,^{4–9} as described in our previous reports.^{1–3} Testing was performed with Finn Chambers (Epitest Ltd Oy) on Scanpor tape (Norgesplaster Aksjeselskap). Allergens were acquired from Chemotechnique MB Diagnostics AB and from allergEAZE (SmartPractice Canada) or by specific compounding, which was requested from our pharmacy as needed. Patches were generally applied to the upper backs of patients. After the initial application, patches were removed at 48 hours, with the first evaluation at 48 hours and the second evaluation at 96 to 168 hours.

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The ordering physician read and documented the patch test results in conjunction with a nurse who was specially trained in patch testing. Interpretation of the patch test results (irritant vs allergic; relevancy) was performed and documented by the ordering physician. All aspects of the patch testing were under the supervision of the Mayo Clinic Contact Dermatitis Group—physicians specializing in patch testing (the coauthors of this article). The level of supervision varied depending on the experience of the ordering physician. The Contact Dermatitis Group also supervised the group of nurses specializing in patch testing.

Similar to previous reports, reactions were rated as negative, irritant, weak (nonvesicular erythema, infiltration, or papules), strong (edema or vesicles), or extreme (spreading, bullous, or ulcerative lesions).^{1–3} For the purposes of this study, macular erythema and doubtful reactions were classified as a negative reaction. At the final reading, a positive allergic patch test result was defined as a weak, strong, or extreme reaction.

RESULTS

During the 5-year study period, 2582 patients were patch tested (mean [SD] age, 53.4 [17.4] years). Of these patients, 843 (32.7%) were male, and 1739 (67.4%) were female. Of the 2582 patients, 1566 (60.7%) had at least 1 positive reaction, with 558 (35.6%) having 1 positive reaction and 1008 (64.4%) having 2 or more positive reactions. Of the 2582 patients, 516 (20.0%) had 1 or more reactions classified as irritant, with 248 (9.6%) having 1 reaction and 268 (10.4%) having 2 or more irritant reactions.

Table 1 presents the reaction rates of individual allergens for the 5-year study period alongside the 2011–2012⁴ and 2013–2014⁵ NACDG reaction rates. Over the study period, we have added 7 allergens and removed 6 from the standard series. Table 2 lists the additions and deletions to the Mayo Clinic current standard series and the reason for each change.

DISCUSSION

In this study, we report the 2011–2015 trends for patch test results with the Mayo Clinic standard series. We patch test to some allergens not tested by NACDG (and vice versa) or at different concentrations to NACDG. Since our last report, allergens have been added or deleted or are tested in different concentrations. For the purposes of this study, macular erythema and doubtful reactions were classified as negative.

Of the 73 allergens in our standard series, 34 (46.6%) were associated with reaction rates of less than 1% of the patients who were patch tested. Although these allergens have low reaction rates, we still feel that they have utility in the standard series because they are common ingredients of many skin care products of patients receiving patch testing.

Many of the allergens tested may be associated with irritancy. Only 3 allergens were associated with irritancy in more than 2% of

the patients tested: cobalt (II) chloride hexahydrate, 1% (3.1%); carba mix, 3% (2.6%); and *Myroxylon pereirae* resin, 25% (2.1%).

When comparing our current data with those of our previous series,³ 12 (80%) of the 15 allergens with the highest reaction rates remained consistent. New to the top 15 allergens in the current series (Table 3) are methylisothiazolinone (MI) (#2) and methyldibromoglutaronitrile (#15), which were not included with the same formulation previously, and methylchlorisothiazolinone (MCI)/MI (currently #10, previously #18). No longer in the top 15 in the current series are methyldibromoglutaronitrile/phenoxylethanol (currently a new formulation, previously #11), benzoic acid (currently #16, previously #13), and fragrance mix II (currently #21, previously #12).

Twelve (80%) of the 15 allergens (Table 3) with the highest reaction rates were largely similar to those published by NACDG, including metals (nickel and cobalt), preservatives (MI, MCI/MI, formaldehyde, quaternium-15, methyldibromoglutaronitrile), markers of fragrance (*M. pereirae* resin, fragrance mix), topical antibiotics (neomycin, bacitracin), and rubber (carba mix). Allergens with high reaction rates not included in the top 15 most common allergens of the NACDG series⁵ were benzalkonium chloride (BAK), methyldibromoglutaronitrile, and potassium dichromate.

It is interesting that the 3 allergens that are in our top 15 but not the NACDG top 15 all had high rates of weak positive reactions: BAK, 93.2%; methyldibromoglutaronitrile, 88.1%; and potassium dichromate, 83.9%. There is an “art” to reading patch tests, part of which is the interpretation of these weak reactions. It is possible that we are overcalling these results, but this seems unlikely for 2 reasons. First, as detailed in the Methods section, *weak reactions* are defined as nonvesicular erythema, infiltration, or papules; *doubtful reactions* (macular erythema), often the most difficult to determine relevance, were counted as negative. Second, for most of the allergens, our results have similar positivity as the NACDG; if we were overcalling these results, our positivity rates would be higher for most allergens. Ultimately, a weak reaction can be determined as being truly allergic only after longitudinally observing whether the skin improves with avoidance and gets worse without avoidance.

Benzalkonium Chloride

Benzalkonium chloride is a cationic quaternary ammonium compound found in various health care products (sterilization of instruments, hand sanitizers, eye products), household products (floor cleaners, disinfectants), and personal care products, given its antiseptic properties. Our experience has been previously outlined.¹⁰ Using the SkinSAFE database,¹¹ which tracks allergens in personal care products, 10,998 products contained BAK or one of its cross-reactors (other quaternary ammonium compounds, such as benzethonium chloride); all are liquid products, such as moisturizers, liquid soaps, shampoos, and conditioners. Benzalkonium chloride was previously believed to be a common irritant with low potential for sensitization.^{12–14} It was declared a “problematic” patch test preparation by the NACDG because of its high positivity

TABLE 1. Patch Test Reactions to the Mayo Clinic Institution's Standard Series (2011–2015) Compared With NACDG (2011–2012 and 2013–2014)

Present Study (2011–2015)																	
Allergen*	Patients Tested	Patients With Reaction, No. (%)		Reaction Grade of Patients With Allergic Reactions, No. (%)				NACDG, 2011–2012		NACDG, 2013–2014							
		Allergic	Irritant	Weak	Strong	Extreme	Patients Tested	Patients With Allergic Reaction, %	Patients Tested	Patients With Allergic Reaction, %							
Nickel sulfate hexahydrate, 2.5% MI, 0.2% aqueous <i>M. pereirae</i> resin, 25% Neomycin sulfate, 20% Cobalt (II) chloride hexahydrate, 1% BAK, 0.1% aqueous Fragrance mix, 8% Potassium dichromate, 0.25% Bacitracin, 20% MCI/MI, 100 ppm aqueous Carba mix, 3% Formaldehyde, 1% aqueous <i>p</i> -Phenylenediamine, 1% Quaternium-15, 1% Methyldibromo glutaronitrile, 0.5% Benzoic acid, 5% Propolis, 10% Thiuram mix, 1% Iodopropenyl butylcarbamate, 0.2% Hexahydro-1,3,5- <i>tris</i> (2-hydroxyethyl)triazine, 1% Fragrance mix II Colophonium, 20% Disperse orange 3, 1% Cocamidopropyl betaine, 1% aqueous Amidoamine, 0.1% aqueous Propylene glycol, 20% in water 2-Bromo-2-nitropropane-1,3-diol, 0.5% Glyceryl thioglycolate, 1% Tixocortol-21-pivalate, 1% Compositae mix II, 5% Lanolin alcohol, 30% Hexylresorcinol, 0.25% Benzocaine, 5% Ethylenediamine dihydrochloride, 1% Methyl methacrylate, 2%	2565	469 (18.3)	36 (1.4)	245 (52.2)	147 (31.3)	77 (16.4)	4224	18.5	4850	20.1							
	964	131 (13.6)	9 (0.9)	91 (69.5)	27 (20.6)	13 (9.9)	NT	NT	4857	10.9							
	2573	236 (9.2)	54 (2.1)	201 (85.2)	30 (12.7)	5 (2.1)	4234	7.9	4859	7.2							
	2574	201 (7.8)	22 (0.9)	114 (56.7)	56 (27.9)	31 (15.4)	4229	9.1	4857	8.4							
	2569	197 (7.7)	80 (3.1)	125 (63.5)	53 (26.9)	19 (9.6)	4231	7.3	4859	7.4							
	2546	176 (6.9)	36 (1.4)	164 (93.2)	10 (5.7)	2 (1.1)	NT	NT	NT	NT							
	2575	173 (6.7)	25 (1.0)	120 (69.4)	42 (24.3)	11 (6.4)	4232	12.1	4858	11.9							
	2571	168 (6.5)	38 (1.5)	141 (83.9)	23 (13.7)	4 (2.4)	4235	1.6	4859	2.2							
	2572	165 (6.4)	19 (0.7)	79 (47.9)	48 (29.1)	38 (23.0)	4234	7.8	4858	7.4							
	2576	152 (5.9)	16 (0.6)	115 (75.7)	34 (22.4)	3 (2.0)	4227	5.0	4856	6.4							
	2573	150 (5.8)	66 (2.6)	114 (76.0)	30 (20.0)	6 (4.0)	4236	4.7	4859	4.8							
	2572	133 (5.2)	18 (0.7)	109 (82.0)	20 (15.0)	4 (3.0)	4237	6.6	4858	5.6							
	2568	114 (4.4)	17 (0.7)	52 (45.6)	35 (30.7)	27 (23.7)	4223	6.3	4853	7.0							
	2573	113 (4.4)	26 (1.0)	68 (60.2)	33 (29.2)	12 (10.6)	TADC	TADC	4856	4.8							
	987	42 (4.3)	4 (0.4)	37 (88.1)	4 (9.5)	1 (2.4)	NT	NT	NT	NT							
	2574	94 (3.7)	30 (1.2)	84 (89.4)	9 (9.6)	1 (1.1)	NT	NT	NT	NT							
	1689	59 (3.5)	15 (0.9)	49 (83.1)	9 (15.3)	1 (1.7)	4231	1.8	4859	1.7							
	2573	72 (2.8)	15 (0.6)	39 (54.2)	24 (33.3)	9 (12.5)	4236	2.9	4859	3.1							
	2555	71 (2.8)	24 (0.9)	68 (95.8)	3 (4.2)	0 (0.0)	TADC	TADC	TADC	TADC							
	2573	68 (2.6)	19 (0.7)	58 (85.3)	9 (13.2)	1 (1.5)	NT	NT	NT	NT							
	2572	67 (2.6)	25 (1.0)	58 (86.6)	7 (10.4)	2 (3.0)	4237	5.2	4859	5.7							
	2574	63 (2.4)	29 (1.1)	34 (54.0)	19 (30.2)	10 (15.9)	4236	2.3	4858	1.9							
	2573	61 (2.4)	21 (0.8)	23 (37.7)	25 (41.0)	13 (21.3)	NT	NT	NT	NT							
	2573	58 (2.3)	38 (1.5)	55 (94.8)	2 (3.4)	1 (1.7)	4232	1.4	4859	1.6							
	2515	56 (2.2)	26 (1.0)	46 (82.1)	8 (14.3)	2 (3.6)	4231	1.2	4859	1.2							
2570	55 (2.1)	15 (0.6)	48 (87.3)	6 (10.9)	1 (1.8)	TADC	TADC	TADC	TADC								
2571	52 (2.0)	22 (0.9)	35 (67.3)	15 (28.8)	2 (3.8)	4231	1.6	4859	2.1								
2573	49 (1.9)	27 (1.0)	41 (83.7)	6 (12.2)	2 (4.1)	NT	NT	NT	NT								
2574	47 (1.8)	9 (0.3)	25 (53.2)	12 (25.5)	10 (21.3)	4230	2.3	4859	2.1								
2215	39 (1.8)	9 (0.4)	23 (59.0)	8 (20.5)	8 (20.5)	NT	NT	NT	NT								
2572	42 (1.6)	26 (1.0)	33 (78.6)	6 (14.3)	3 (7.1)	TADC	TADC	TADC	TADC								
2573	39 (1.5)	22 (0.9)	39 (100.0)	0 (0.0)	0 (0.0)	NT	NT	NT	NT								
2569	35 (1.4)	10 (0.4)	26 (74.3)	6 (17.1)	3 (8.6)	4236	1.4	4851	1.6								
2574	37 (1.4)	17 (0.7)	16 (43.2)	15 (40.5)	6 (16.2)	4232	1.3	4859	1.2								
2573	33 (1.3)	26 (1.0)	26 (78.8)	7 (21.2)	0 (0.0)	4236	0.9	4859	1.3								

Tea tree oil oxidized, 5%	1687	22 (1.3)	6 (0.4)	15 (68.2)	6 (27.3)	1 (4.5)	4231	0.9	4859	0.9
Diazolidinyl urea, 1%	2576	31 (1.2)	29 (1.1)	21 (67.7)	7 (22.6)	3 (9.7)	4232	2.1	4858	1.6
Black rubber mix, 0.6%	2573	29 (1.1)	11 (0.4)	19 (65.5)	8 (27.6)	2 (6.9)	4236	1.3	4859	1.0
Ethyl acrylate, 0.1%	2573	27 (1.0)	21 (0.8)	17 (63.0)	6 (22.2)	4 (14.8)	4230	0.9	4859	1.1
Cinnamal (cinnamic aldehyde), 1%	2571	24 (0.9)	10 (0.4)	23 (95.8)	1 (4.2)	0 (0.0)	4231	3.9	4858	4.2
Cocamide DEA (coconut diethanolamide), 0.5%	2574	23 (0.9)	28 (1.1)	20 (87.0)	2 (8.7)	1 (4.3)	4230	0.9	4859	0.9
Epoxy resin, bisphenol A	2574	23 (0.9)	22 (0.9)	12 (52.2)	6 (26.1)	5 (21.7)	4235	1.5	4857	1.8
Imidazolidinyl urea, 2%	2572	22 (0.9)	19 (0.7)	16 (72.7)	6 (27.3)	0 (0.0)	4232	1.6	4859	1.6
Ethyleneurea, melamine formaldehyde mix, 5%	2573	20 (0.8)	25 (1.0)	15 (75.0)	4 (20.0)	1 (5.0)	NT	NT	NT	NT
Paraben mix, 16%	2576	20 (0.8)	32 (1.2)	17 (85.0)	3 (15.0)	0 (0.0)	TADC	TADC	TADC	TADC
DMDM hydantoin, 2% aqueous	2573	21 (0.8)	12 (0.5)	16 (76.2)	5 (23.8)	0 (0.0)	NT	NT	NT	NT
Disperse blue mix 106/124, 1%	1687	13 (0.8)	14 (0.8)	10 (76.9)	3 (23.1)	0 (0.0)	4228	1.0	4859	1.0
Imidazolidinyl urea, 2% aqueous	2575	18 (0.7)	28 (1.1)	10 (55.6)	5 (27.8)	3 (16.7)	NT	NT	NT	NT
Mixed dialkyl thioureas, 1%	2573	19 (0.7)	17 (0.7)	5 (26.3)	9 (47.4)	5 (26.3)	4231	0.7	4859	1.0
Sesquiterpene lactone mix, 0.1%	2539	19 (0.7)	18 (0.7)	8 (42.1)	4 (21.1)	7 (36.8)	4230	0.7	4859	0.9
Phenol formaldehyde resin, 1%	2573	17 (0.7)	22 (0.9)	15 (88.2)	1 (5.9)	1 (5.9)	NT	NT	NT	NT
Budesonide, 0.01%	2575	18 (0.7)	10 (0.4)	9 (50.0)	7 (38.9)	2 (11.1)	4232	0.8	NT	NT
Benzophenone-3, 10%	2539	12 (0.5)	7 (0.3)	7 (58.3)	3 (25.0)	2 (16.7)	4231	0.8	4859	0.6
DMDM hydantoin, 1%	2574	13 (0.5)	24 (0.9)	8 (61.5)	4 (30.8)	1 (7.7)	4232	1.6	4859	1.0
Chloroxylenol (PCMX), 1%	2573	13 (0.5)	16 (0.6)	10 (76.9)	2 (15.4)	1 (7.7)	4230	0.5	4859	0.5
(±)-a-Tocopherol, 100% (vitamin E)	2574	13 (0.5)	17 (0.7)	9 (69.2)	4 (30.8)	0 (0.0)	4230	0.7	4859	0.6
4-tert-Butylphenol formaldehyde resin, 1%	2573	11 (0.4)	21 (0.8)	6 (54.5)	3 (27.3)	2 (18.2)	4235	1.1	4859	1.0
Toluenesulfonamide formaldehyde resin, 10%	2573	11 (0.4)	28 (1.1)	9 (81.8)	2 (18.2)	0 (0.0)	4232	1.2	4859	0.9
Lidocaine, 5%	2572	11 (0.4)	31 (1.2)	8 (72.7)	2 (18.2)	1 (9.1)	TADC	TADC	TADC	TADC
Glutaral (glutaraldehyde), 0.2%	2574	8 (0.3)	28 (1.1)	6 (75.0)	2 (25.0)	0 (0.0)	TADC	TADC	TADC	TADC
Hydrocortisone 17-butyrate, 1% alcohol	2566	7 (0.3)	6 (0.2)	5 (71.4)	2 (28.6)	0 (0.0)	4231	0.3	4859	0.1
Mercapto mix, 1%	2571	8 (0.3)	17 (0.7)	7 (87.5)	0 (0.0)	1 (12.5)	4236	0.5	NT	NT
Sorbic acid, 2%	2573	7 (0.3)	11 (0.4)	7 (100.0)	0 (0.0)	0 (0.0)	NT	NT	NT	NT
Stearyl alcohol, 30%	2574	8 (0.3)	9 (0.3)	8 (100.0)	0 (0.0)	0 (0.0)	NT	NT	NT	NT
Triethanolamine, 2%	2574	9 (0.3)	20 (0.8)	9 (100.0)	0 (0.0)	0 (0.0)	NT	NT	NT	NT
Mercaptobenzothiazole, 1%	2573	9 (0.3)	22 (0.9)	5 (55.6)	2 (22.2)	2 (22.2)	4236	0.5	4859	0.5
BHT (2,6-di-tert-butyl-p-cresol), 2%	2574	5 (0.2)	20 (0.8)	2 (40.0)	3 (60.0)	0 (0.0)	NT	NT	NT	NT
Dimethyl dihydroxyethyleneurea, 4.5% aqueous	2573	6 (0.2)	24 (0.9)	6 (100.0)	0 (0.0)	0 (0.0)	NT	NT	NT	NT
Sorbitan sesquioleate, 20%	1689	4 (0.2)	12 (0.7)	4 (100.0)	0 (0.0)	0 (0.0)	NT	NT	NT	NT
Cetyl alcohol, 5%	2574	4 (0.2)	6 (0.2)	4 (100.0)	0 (0.0)	0 (0.0)	NT	NT	NT	NT
Clobetasol-17-propionate, 1%	2572	5 (0.2)	8 (0.3)	3 (60.0)	2 (40.0)	0 (0.0)	4230	0.3	4,859	0.1
2-Phenoxyethanol, 1%	988	2 (0.2)	3 (0.3)	2 (100.0)	0 (0.0)	0 (0.0)	NT	NT	NT	NT
Triamcinolone acetonide, 1%	2561	2 (0.1)	8 (0.3)	1 (50.0)	1 (50.0)	0 (0.0)	NT	NT	NT	NT

*Allergens are listed from the highest to lowest reaction rates. Allergens listed were in the standard series at the completion of the study (December 31, 2015). Allergens were in petrolatum unless otherwise specified (eg, aqueous or alcohol).

BHT indicates butylated hydroxytoluene; DMDM, 1,3-dimethylol-5,5'-dimethyl; NT, not tested; PCMX, chloroxylenol; TADC, tested at a different concentration.

TABLE 2. Mayo Clinic Standard Series Additions and Deletions After 2010

Allergen	Source of Exposure	Reason for Change
Additions		
Compositae mix II, 5%	Flowering plants	Added after Compositae mix was discontinued by manufacturer
Disperse blue mix 106/124, 1%	Textile dye	Combination of previously used disperse blue dyes 106 and 124
Methyldibromo glutaronitrile, 0.5%	Preservative	Separated from methyldibromo glutaronitrile/phenoxyethanol mix to determine which was responsible for increasing reaction rate
MI, 0.2% aqueous	Preservative	Monitor to determine whether MI would cause reactions out of the MCI/MI mix
2-Phenoxyethanol, 1%	Antiseptic, preservative	Separated from methyldibromo glutaronitrile/phenoxyethanol mix to determine which was responsible for increasing reaction rate
Propolis, 10%	Skin care products	Increasing use in skin care products
Sorbitan sesquioleate, 20%	Emulsifier	Better coverage of personal care products
Deletions		
Compositae mix, 5%	Flowering plants	Discontinued by manufacturer; replaced by Compositae mix II
Disperse blue 106, 1%	Textile dye	Discontinued with availability of disperse blue mix 106/124, which adequately represents both allergens
Disperse blue 124, 1%	Textile dye	Discontinued with availability of disperse blue mix 106/124, which adequately represents both allergens
Isopropyl myristate, 20%	Skin care products	Removed from the standard series because of a low reaction rate; added to cosmetic series
Methyldibromo glutaronitrile/ phenoxyethanol, 1.5%	Preservative	Concentration lowered to 1.0% in 2012; then separated into separate components to determine which allergen was responsible for increasing reaction rate
Triclosan, 2%	Antiseptic, preservative	Removed from the standard series because of a low reaction rate; added to cosmetic series

ratio (amount of weak reactions divided by the total reactions) and low reaction index (amount of total reactions minus questionable and irritant reactions, divided by total reactions)¹⁵ and was thereafter removed from the NACDG standard series.

Nonetheless, there have been numerous reports of BAK causing allergic reactions, particularly among health care workers.^{10,16,17} In

a retrospective review of 615 patients patch tested with BAK, Isaac and Scheinman¹⁷ found that 198 patients (32%) had positive patch test reactions. Most patients had exposure to at least 1 BAK-containing product that corresponded to the area of dermatitis. In the past 15 years, BAK has consistently been among the most commonly positive allergens in our standard series, with relatively low

TABLE 3. Top 15 Allergens of the Mayo Clinic Standard Series (2011–2015) Compared With NACDG (2011–2012 and 2013–2014)*†

Rank	Current Study, 2011–2015	NACDG, 2011–2012	NACDG, 2013–2014
1	Nickel sulfate hexahydrate	Nickel sulfate hexahydrate	Nickel sulfate hexahydrate
2	MI	Fragrance mix I	Fragrance mix I
3	<i>M. pereirae</i> resin	Neomycin sulfate	MI
4	Neomycin sulfate	<i>M. pereirae</i> resin	Neomycin sulfate
5	Cobalt (II) chloride hexahydrate	Bacitracin	Cobalt (II) chloride hexahydrate
6	BAK	Cobalt (II) chloride hexahydrate	Bacitracin
7	Fragrance mix I	Formaldehyde, 1.0%	<i>M. pereirae</i> resin
8	Potassium dichromate	Quaternium-15	<i>p</i> -Phenylenediamine
9	Bacitracin	<i>p</i> -Phenylenediamine	Formaldehyde, 2.0%
10	MCI/MI	Fragrance mix II	MCI/MI
11	Carba mix	MCI/MI	Fragrance mix II
12	Formaldehyde, 1.0%	Carba mix	Formaldehyde, 1.0%
13	<i>p</i> -Phenylenediamine	Lanolin alcohol	Lanolin alcohol
14	Quaternium-15	Iodopropynyl butylcarbamate	Quaternium-15
15	Methyldibromo glutaronitrile	Cinnamal	Carba mix

*Allergens are listed from the highest to lowest reaction rates for each series.

†Allergens in bold font were included in our top 15 but not in the top 15 of either NACDG series.

rates of irritancy.^{1–3} Clinician vigilance should remain high for BAK given its increasing and high reaction rate and the extremely common use of quaternary ammonium compounds in skin care products. It is possible that a current wave of BAK contact allergy is a result of skin care product manufacturers seeking alternatives to preservatives such as formaldehyde releasers and MI.

Potassium Dichromate

Potassium dichromate is a chromium (VI) compound used in manufacturing (cement, creation of chrome steel and chrome-nickel-steel alloys) and household products (leather, glues, polishes). Chromium is used to tan leather and can cause allergic contact dermatitis of the feet from wearing treated shoes or of the hands when leather gloves are worn. It is important for patch test specialists to recognize that this substance can tan the skin when applied under Finn Chambers. This commonly imparts a red-brown color to the skin when reading patch test results. Our group's 6.5% reaction rate is approximately 3 times that of recent data from the NACDG.⁵ It is conceivable that our increased reaction rate could be due to an altered perception of a true-positive reaction from the tanning of the skin from this allergen, although we have endeavored to avoid this misreading.

Methyldibromo Glutaronitrile

Methyldibromo glutaronitrile is a preservative found in personal care products, paints, and wood. Because of reports of increased sensitization from personal care products, it was banned in 2005 from leave-on products and in 2008 from rinse-off products in European Union member states.^{18,19} However, this ban did not extend to North American products; in review of the SkinSAFE database,¹¹ methyldibromo glutaronitrile is currently found in 29 products, most notably sunscreens, hair care products, and toners. In our standard series, we transitioned from a combination methyldibromo glutaronitrile/phenoxyethanol, 1.5%, to methyldibromo glutaronitrile, 0.5%, in the middle of the study period to distinguish it from possible allergies to phenoxyethanol. Despite this change, reaction rates have continued to be notably high for methyldibromo glutaronitrile alone. The NACDG does test methyldibromo glutaronitrile in combination with phenoxyethanol, 2%. It is interesting to note that the rate of positive reactions for methyldibromo glutaronitrile in combination with phenoxyethanol was similarly high, ranking 16th (3.7%) in the 2011–2012 report⁴ and 19th (3.7%) in the 2013–2014 report.⁵

CONCLUSIONS

We have presented the 2011–2015 patch test trends for patients tested at 3 geographically separated locations of our institution. With a few exceptions, our rates of positive patch test reactions to allergens are similar to those of the NACDG and our previously reported results. Particular allergens that

continue to trend are MCI/MI (which increased from our previous series) and BAK, which is not included in the NACDG standard series.

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