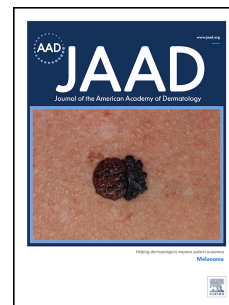


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Patch Testing with Ammonium Persulfate: The North American Contact Dermatitis Group Experience, 2015-2018

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Title: Patch Testing with Ammonium Persulfate: The North American Contact Dermatitis Group Experience, 2015-2018

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Capsule Summary:

- Historically, allergy to ammonium persulfate has been associated with hair bleaching agents, especially in hairdressers.
- In this retrospective review of 10,526 routinely patch-tested patients, 193 (1.8%) had positive patch test reactions to ammonium persulfate. Males had a significant higher frequency of positivity and hot tub/pool exposures were common.

Abstract:

Background: Ammonium persulfate (APS), an oxidizing agent used in hair products, manufacturing, and pool/spa water, can cause skin reactions including allergic contact dermatitis.

Objective: To characterize positive patch test reactions to APS (2.5% pet).

Methods: Retrospective analysis of patients tested to the North American Contact Dermatitis Group (NACDG) screening series from 2015-2018.

Results: Of 10,526 patients, 193 (1.8%) had positive patch test reactions to APS. Compared to negative patients, APS-positive patients were significantly more likely to be male (43.2% vs. 28.0%, $p<0.0001$), have primary hand (30.2% vs. 22.0%, $p=0.0064$), scattered generalized (25.5% vs. 17.9%, $p=0.0064$), or trunk dermatitis (8.9% vs. 4.9%, $p=0.0123$), and occupationally-related dermatitis (22.2% vs. 10.9%, $p<0.0001$). Over half of the APS-positive reactions were currently relevant (57.0%); 19 (9.8%) were related to occupation, especially (68.4%) hairdressers. Swimming pools/spas (23.3%) and hair care products (19.2%) were the most common APS sources.

Limitations: Immediate reactions and follow-up testing not captured.

Conclusions: The proportion of patients positive to APS was 1.8%. APS positivity was significantly associated with male sex and hand dermatitis. Swimming pool/spa chemicals are important sources of APS exposure.

Introduction:

Persulfates, including ammonium (APS), potassium (PPS), and sodium persulfate (NaPS), are oxidizing agents used in chemicals, textiles, pharmaceuticals, foods, photographs, and cosmetics.¹ APS is an inorganic salt commonly used in hair bleach formulations and cold wave applications.² In 2017, the Cosmetic Ingredient Review (CIR) Expert Panel noted 36 cosmetic product formulations containing APS, 94.4% (34/36) of which were hair coloring/bleaching products.³ Cross-reactivity between persulfates is expected, as persulfates share similar chemical structures, multiple persulfates are often used together (particularly in hair bleach), APS is used to manufacture other persulfates, and the epitope is the persulfate portion of the molecule.¹

Persulfates, especially APS, may cause immediate-type reactions (e.g. contact urticaria, rhinitis, asthma, angioedema, anaphylaxis),^{1,2,4-12} particularly in hairdressers exposed to bleaching chemicals, which contain a mixture of different persulfates in concentrations up to 60%.³ Persulfates accelerate the bleaching process and make the hair more susceptible to dyeing.¹³

Persulfates may also cause irritant contact dermatitis (ICD) and allergic contact dermatitis (ACD). The first case of ACD to persulfates was reported in flour blanching/strengthening agents used by European bakers.¹⁴ In the 1950s, several European countries banned the use of persulfates in the baking industry due to an epidemic of hand dermatitis among bakers.¹

Sensitization to APS has been evaluated in select patient populations, most commonly in hairdressers (**Table 1**).¹⁵⁻³⁷ In studies reporting clinical relevance, up to 90% of patch test reactions to APS were relevant (current vs. past relevance not specified).^{1,24,25,36} While prevalence of positive patch test reactions to APS in selected populations has been reported,

detailed reaction characteristics, clinical relevance, sources, and patient demographic information is lacking. Here, we address these deficiencies.

Methods:

NACDG Database

This retrospective analysis was approved by the Minneapolis Veterans Affairs Medical Center's Subcommittee on Human Studies. In 2015, APS 2.5% pet (AllergEAZE, Calgary, Alberta, Canada) was added to the North American Contact Dermatitis Group (NACDG) screening series. Patient demographic information (age, sex, race, occupation), history of atopy, anatomic site(s) of dermatitis (up to 3 sites), and final diagnosis (up to 3 different diagnoses) were collected.

Patch test reactions were evaluated at 48 and 72-168 hours after placement. Reactions were graded as weak + (nonvesicular, erythematous infiltration), strong ++ (edematous or vesicular), extreme +++ (spreading, bullous, or ulcerative), doubtful +/- (macular erythema), irritant, or negative. A final interpretation code of "allergic" or "not allergic" was also determined by each investigator based on the temporal pattern (crescendo/decrecendo), patch test appearance, and known characteristics of that allergen. Reactions with a final interpretation of allergic were considered "positive" and not allergic were considered "negative". For each positive reaction, clinical relevance was coded: "definite" (a positive patch test or use test with a skin contactant verified to contain APS), "probable" (APS present in known skin contactants with a consistent clinical presentation), "possible" (a skin contactant likely contained APS), "past" (the patient was exposed to APS previously and had a clinical reaction, but no current sources were present),

or “unknown.” Occupational relevance was also coded for each positive patch test, either as “yes” (related), “no” (unrelated), or “unsure.” A source of APS exposure was also coded from a list of over 200 categories.

Data Analysis

Data was entered into a centralized location using Microsoft Access software and Microsoft Excel (Microsoft Corporation, Richmond, WA). Two-sided Chi-squared tests were used to test the association between APS-positive and negative patients using GraphPad Prism software (version 8.2.1). Odds ratios (OR) and 95% confidence intervals (CIs) were estimated. *P* values less than 0.05 were considered statistically significant. No adjustments were made for multiple comparisons.

Results:

Demographics

Of the 10,526 patients patch tested to APS, 193 (1.8%) were positive; of these, 34 (17.6%) were only positive to APS. The average age of APS-positive patients was 44.1 years (range 3-83 years) and most were Caucasian (88.4%). Compared to APS-negative patients, APS-positive patients were significantly more likely to be male (43.2% vs. 28.0%, $P < 0.0001$) and have occupationally-related dermatitis (22.2% vs. 10.9%, $P < 0.0001$) (**Table 2**).

Primary Anatomic Site

The hands were the most common primary site of dermatitis in APS-positive patients ($n=58$, 30.2%). Other common anatomic sites included a scattered/generalized pattern (25.5%), the face

(21.9%), and trunk (8.9%). Compared to APS-negative patients, APS-positive patients were 1.54 times more likely to have primarily hand involvement (30.2% vs 22.0%), 1.57 times more likely to have primarily scattered/generalized dermatitis (25.5% vs. 17.9%), and 1.89 times more likely to have primarily trunk involvement (8.9% vs. 4.9%, **Table 3**). APS-positive patients were significantly less likely to have primarily facial dermatitis (21.9% vs. 32.6%) (**Table 3**).

Final Diagnoses

APS-positive patients were significantly more likely to have a final primary diagnosis of ACD as compared to APS-negative patients (80.7% vs. 50.1%, OR 4.17; 95% CI 2.94-6.00; $P < 0.0001$). Contact urticaria was the non-primary diagnosis (up to 3 diagnoses) in one patient.

Reaction Strength, Clinical Relevance, and Occupational Relevance

Over half (52.3%) of positive reactions to APS were + at the 72-168 hour reading; 26.9% were ++, 16.6% were +++, and 4.2% were +/- (**Table 4**). Of the ++/+++ reactions, the most common APS sources were swimming pool/spa water (SPSW) (36.5% of ++ and 18.8% of +++ reactions) and hair care products (HCPs) (13.5% of ++ and 15.6% of +++ reactions). An additional 75 reactions (18 + and 57 +/-) were interpreted as “not allergic” and excluded from the APS-positive group. Over half (57.0%) of the positive APS reactions were currently relevant (definite/probable/possible); however, only two were of “definite” relevance. Forty reactions (20.7%) were of “probable” relevance and 68 (35.2%) were of “possible” relevance.

Ammonium Persulfate Exposure Sources

Swimming pool/spa water was the most frequently identified source of APS exposure, seen in 23.3% of positive reactions. HCPs were coded as the source in 19.2% (especially hair dyes (11.4%)) and disinfectants in 4.7% of positive reactions.

Occupationally Related APS Reactions

Nineteen reactions (9.8%) were considered occupationally-related. Most (n=13, 68.4%) involved hairdressers/cosmetologists, all which had hand dermatitis. Other occupations included teachers (n=2; one with primary hand dermatitis/HCP source and one with primary trunk/SPSW source), a therapist (primary hand dermatitis/HCP source), and a cutlery sales supervisor (primary scattered generalized dermatitis/HCP source).

Discussion:

This is the only study to date to evaluate APS positivity on a screening series. Overall, 1.8% of patients had positive patch reactions to APS. As compared to APS-negative patients, APS-positive patients were more likely to be male, have occupationally-related dermatitis, and present with dermatitis primarily involving the hands or a scattered generalized pattern. Over half of the positive APS reactions were weak and SPSW and HCPs were common sources.

Prevalence of Positive Reactions

A direct comparison of our 1.8% APS-positivity to other studies is limited, as other studies evaluated select patient populations not routinely tested to a screening series (**Table 1**). APS is not on general screening series, including T.R.U.E Test. Joost et al. found that of 2,320 patients with previous positive patch test reactions to screening allergens, 0.9% were positive to APS

and/or PPS on retesting.²⁸ Amin et al.³⁰ reported APS positivity in 2.2% of 1,215 Americans with eyelid dermatitis and Hillen et al. found a 3.2% positivity rate in 634 Europeans with scalp dermatitis.³¹ Toholka et al. found an extremely high prevalence of APS positivity (22.1% in 1,326 patients tested); APS reactions may have been overrepresented in that study, since almost 50% of study patients were referred from an Occupational Dermatology Clinic, “many” (number not reported) of whom were hairdressers.²⁹

Demographics

Males were significantly over-represented in the APS-positive group. Many males had primary hand (36.1%), scattered generalized (30.1%), or trunk involvement (12.0%) (data not previously shown). Of the 83 APS-positive male patients, only 5 worked as hairdressers/cosmetologists. Interestingly, SPSW was the most common (33.7%) source of APS exposure in positive male patients and may explain this high proportion, as males likely perform increased maintenance duties and/or use hot tubs/spas more frequently.³⁸ Male predominance is consistent with previous reports;^{38,39} Gilligan et al. evaluated patients diagnosed with ACD due to persulfates used in hot tub shock treatments, finding that all were men (n=8).³⁸

Over one-third of APS-positive patients in our study had a history of atopic dermatitis; there was no significant association between the prevalence of atopy and APS positivity. O’Connell et al. reported a much lower proportion (13%, 22/169) of atopic dermatitis in APS-positive hairdressers, but similarly, there was no statistical difference in APS-sensitivity between those with and without atopic dermatitis.¹⁹

While most (60.2%) of the APS-positive patients in our study were >40 years old, APS-positive patients tended to be younger than APS-negative patients (44.1 vs. 48.1 years). Wang et al. evaluated 210 patients suspected of ACD to hairdressing chemicals and found that positive reactions to APS were significantly higher among younger patients (<30 years), possibly due to more frequent exposure to hairdressing products.³⁶ Notably, 15.7% of their study patients were cosmetologists/beauticians,³⁶ who tend to be younger than non-hairdresser patients.⁴⁰

Anatomic Sites

The most common primary anatomic sites of dermatitis in APS-positive patients were the hands (30.2%), a scattered/generalized pattern (25.5%), and the face (21.9%). Of the positive patients with primary hand involvement (n=58), HCPs were the most common sources of exposure (32.8%) and hairdresser was the most common occupation (25.9%); this association is well-documented (**Table 1**).¹⁵⁻³⁷

Unlike hairdressers, clients allergic to APS due to HCPs typically present with face and/or scalp dermatitis. Guerra et al. found that of 261 hairdressing clients examined for contact dermatitis, 176 (67.4%) had facial dermatitis, of which 60 had scalp involvement.³⁵ Uter et al. found that 75.4% of clients suspected of contact dermatitis from hair products (n=780) presented with dermatitis involving the head, face, or neck.¹⁸ No previous studies have evaluated sites of dermatitis specifically in APS-positive patients. In our study, 48 (25.0%) APS-positive patients had primary facial or scalp dermatitis, 14 (29.2%) of which were associated with HCPs; only 2 patients in this subgroup were hairdressers. Persulfate powder is mixed with hydrogen peroxide solution during hair bleach preparation;⁴¹ exposure to persulfate-containing dust (potentially

causing airborne contact dermatitis) can be minimized by substituting powdered hair bleach with granular formulations.¹¹ None of the patients in our study with scattered generalized dermatitis were hairdressers.

Of 49 APS-positive patients with primary scattered generalized dermatitis, 22 (44.9%) were associated with SPSW. ACD to persulfates in shock treatments/pool sanitizing agents may present with widespread/generalized dermatitis.^{38,42-44} Clark et al. recently described an APS-positive patient with generalized dermatitis correlating to the patient's posture while in the spa/hot tub (sparing the skin folds and face).⁴³ It is recommended that all patients with generalized dermatitis be asked about hot tub/pool use, especially middle-aged males.³⁸

Ammonium Persulfate Reactions

Over half (52.3%) of the positive reactions were weak (+). "Problematic" patch test preparations (high proportions of weak/irritant/doubtful reactions) can be numerically defined as those with a positivity ratio (PR) >55% and reaction index (RI) ≤ 0.46 .⁴⁵ Here, calculated values for APS (PR-54.6%; RI-0.37) are indicative of "problematic" preparation. Therefore, patch test reactions, especially weak (+) and doubtful (+/-) reactions, should be interpreted carefully.^{24,46} Here, 75 reactions (18 + and 78 +/- irritant) were determined to be "negative/irritant/not allergic," a prevalence of 0.7% (data not shown). APS is known to cause irritant patch test reactions, with reported rates ranging from 2.4% (N=209)³⁶ to 7.4% (N=27).³²

Of APS-positive reactions, 57.0% were currently relevant; only 1.0% of these were "definite" (positive ROAT or patch test to source containing APS); it should be noted, however, that testing

with suspected products to prove “definite” relevance is often not done. An additional 20.7% of APS-positive reactions were “probably” relevant (confirmation of presence in product contacting affected anatomic site) and 35.2% “possibly” relevant (likely presence in product contacting affected anatomic site); this reflects the difficulty in confirming/testing for persulfates in SPSW (not readily available if at a commercial facility) and hair bleaching agents (available typically only in commercial salons).

Sources and Management

SPSW, HCPs, and non-skin disinfectants were the most frequent sources associated with APS reactions. Since cross-reactivity between persulfates (APS and PPS, APS and potassium peroxymonosulfate (PPMS), APS and NaPS) is common, all persulfates should be avoided in individuals with APS-sensitization.^{28,38,39,42,47-49} When creating a “safe” list of products in the American Contact Dermatitis Society (ACDS) Contact Allergen Management Program (CAMP) for patients with positive APS patch test reactions, all persulfates are excluded.⁵⁰ Importantly, sulfites, antioxidants used as preservatives in cosmetics, food, drugs, and photography, are chemically unrelated to persulfates with different structural and chemical properties, and avoidance is not necessary for APS-positive patients.^{51,52}

SPSW was the most common source among APS-positive males (33.7%). Spas/pools use a two-part sanitation processes, which includes daily sanitation and periodic shock treatments to oxidize and eliminate contaminants.^{38,42} PPMS, a potassium triple salt and common oxidizing agent used in pool/spa shock treatments, has cross-reactivity with APS.³⁸ Gilligan et al. described 8 men with generalized dermatitis diagnosed with ACD due to PPMS in hot tub shock

treatments; 6 patients were positive to PPMS and 7 to APS on patch testing. The authors concluded that testing to APS is an adequate screening for allergy to PPMS.^{38,39} For individuals with persulfate allergy, persulfate-free hot tub/pool shock treatments can be substituted (**Table 5**).

Persulfate-free hair bleach/highlighting agents are limited. Dust-free powder products minimize, but do not eliminate APS exposure.⁵³ Bleaching products list “ammonia-free” on the packaging, but often contain other persulfates. We contacted 8 hair salons in our local area (Minneapolis, MN) and found that none carried a professional persulfate-free hair bleach. This limits APS-allergic patients to using hair dyes in blonde/lighter hair color shades, as these commonly contain hydrogen peroxide rather than persulfates. An exhaustive search found few hair lightener/bleach/colorant options free of persulfates (**Table 5**).

The third most frequent source of APS exposure was non-skin disinfectants. While none of the household disinfectants in the ACDS CAMP database contain persulfates,⁵⁰ detergents/disinfectants may contain persulfates as oxidizers, as they are considered less irritating and corrosive than bleach.^{54,55} Specifically, veterinary surface disinfectants contain PPMS. Persulfates can also be found in effervescent denture cleaners.^{49,56}

Other reported sources of APS include kitty litter (increase absorption capacity), bagpipe drying materials (anticorrosion catalyst),⁴² chemical analytic agents (phosphate detection in water samples),⁵⁷ and potato flour.⁴⁷

Occupational Considerations

APS-positive patients were significantly more likely to have occupationally-related disease than APS-negative patients. Of the 19 patients with occupationally-related positive APS reactions, most (68.4%) were hairdressers/cosmetologists; other occupations included teachers (10.5%), therapists (5.3%), and sales supervisors (5.3%). Previously reported prevalence of APS sensitivity in hairdressers varies depending on the study (**Table 1**). Wearing protective gloves, particularly when performing highlights and rinsing bleaching chemicals, packaging hair bleach chemicals to limit direct contact, and mixing bleaching chemicals in designated salon areas to minimize skin contact can help mitigate exposures.¹¹

Limitations:

The study population consisted of patients referred for patch testing, limiting generalizability. Immediate reactions are not recorded in our database. This study was cross-sectional; additional/follow-up testing (e.g., use tests, repeat open application tests, subsequent patch testing) was not captured.

Summary:

The 1.8% prevalence of APS positivity underscores its utility on a screening series. HCPs and SPSW are important sources of APS contact allergy. Weak (+) and doubtful (+/-) reactions to APS should be interpreted carefully.

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525 Table 1. Patch Test Studies Reporting Positive Reactions to Ammonium Persulfate

526 Table 2. MOAFHLA Index Patient Demographics

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529 Table 5. Persulfate-Free Pool/Spa and Hair Bleaches/Lightener Products

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Yrs Tested, Country	No. of Patients/Group tested	Persulfates Patch tested	Proportion of Positive Patch Tests
Studies of HD⁺			
2007-2012, IVDK ¹⁵	696	APS 2.5% pet	18.7%
1995-2002, IVDK ¹⁶	884	APS (conc NR)	26.1%
1988-1991, Europe ¹⁷	809	APS 2.5% pet	8.2%
2003-2006, IVDK ¹⁸	432	APS 2.5% pet	21.7%
1980-2007, UK ¹⁹	538	APS 2.5% pet	10.6%
2002-2011, DCDG ²⁰	397	APS (conc NR)	HD: 10.8%
1980-2003, Spain ^{21,22}	379 (1980-1993) 300 (1994-2003)	APS 2.5% pet	7.9% (1980-1993), 14.3% (1994-2003), significant increase (p<0.05)
1985-1990, Italy ²³	302	APS 2.5% pet.	11.3%
1993-2010, Australia ²⁴	164	APS (conc NR)	47% (87.2% CR)
Years NR, Poland ²⁵	139	APS 2.5% (vehicle NR)	7.9% (90.9% CR)
1985-1994, Greece ²⁶	106	APS 2.5% pet	17.9%
1981-1984, England ²⁷	49	APS 2.5% pet	24.5%
Studies of Selected Patients			
1986-1990, Country NR ²⁸	2,320 patients previously positive to European standard series allergens retested to persulfates	APS 2.5% pet PPS 2% aq	0.9% positive to APS and/or PPS
2007-2012, IVDK ¹⁵	1,692 HDC	APS 2.5% pet	HDC: 2.1%
2001-2010, Australia ²⁹	1,326 patients tested to European standard series and extended series	APS 2.5% pet	22.1% (6% CR)
1995-2002, IVDK ¹⁶	1,217 HDC	APS (conc NR)	HDC: 4.2%
1994-2004, USA ³⁰	1,215 eyelid dermatitis	APS (conc NR)	2.2%
1993-2003, IVDK ³¹	634 scalp dermatitis	APS 2.5% pet	3.2%
2003-2006, IVDK ¹⁸	616 HDC	APS 2.5% pet	2.9%
Years NR, UK ³²	567 tested to hairdressing series	APS 2.5% pet	12.0% of reactions to APS current or past relevance; 2 of 27 patch tests to APS were irritant reactions (data from one centre only).
Jan-April 1996, Europe ³³	475 patients with contact allergy to cosmetics	APS (conc NR)	1.3%
1995-96, 2000-02, Finland ³⁴	395 (1995-1996) and 723 (2000-2002) patients tested to cosmetic-related allergens	APS (conc NR)	2.3% (1995-96) 2.2% (2000-02)
1985-1990, Italy ³⁵	261 HDC	APS 2.5% pet	2.7%
2000-2008, USA ³⁶	210 patients suspected of ACD ^{ss} to hairdressing chemicals	APS 2.5% pet	14.4% (70% CR)
2012-2014, Japan ³⁷	203 patients suspected of ACD to hair dyes or perming solutions	APS 1% pet	Overall: 14.6% HD only: 15.4% (4/26)

571 Table 1. Patch Test Studies Reporting Positive Reactions to Ammonium Persulfate

572 ⁺HD, hairdresser (includes apprentices); APS, ammonium persulfate; NR, not reported; CR, current relevance; HDC, hairdresser client; PPS;

573 ACD, allergic contact dermatitis; IVDK, Information Network of Departments of Dermatology; DCDG, Danish Contact Dermatitis Group

	No. Ammonium Persulfate Positive Patients (%) N = 193	No. Ammonium Persulfate Negative Patients (%) N = 10,333	Odds Ratio (95% CI) p-value
Male	83 (43.2)	2884 (28.0)	1.96 (1.47 – 2.62) $p < 0.0001$
Occupational skin condition**	42 (22.2)	1111 (10.9)	2.34 (1.65 – 3.31) $p < 0.0001$
Atopic Markers			
Asthma	39 (20.6)	1715 (16.8)	1.29 (0.91 - 1.85) 0.1586
Atopic Dermatitis	69 (36.1)	3184 (31.1)	1.26 (0.93 - 1.70) 0.1347
Hay fever	71 (37.4)	3482 (34.0)	1.16 (0.86 - 1.56) 0.3308
Primary Anatomic Site			
Hand	58 (30.2)	2262 (22.0)	1.54 (1.13 – 2.10) 0.0064
Leg	4 (2.1)	345 (3.3)	0.61 (0.24 - 1.59) 0.3322
Face*	42 (21.9)	3354 (32.6)	0.58 (0.41 - 0.81) 0.0017
Age, 40 > y	115 (60.2)	6851 (66.5)	0.76 (0.57 - 1.02) 0.0681

Table 2. MOAFHLA Index Patient Demographics

Available demographic data varied slightly: [ammonium persulfate-positive (sex = missing 1; occupationally related = missing 4; asthma = missing 4; atopic dermatitis = missing 2; hay fever = missing 3; primary anatomic site = missing 1; age = missing 2)], [ammonium persulfate-negative (sex = missing 17; occupationally related = missing 112; asthma = missing 102; atopic dermatitis = missing 84; hay fever = missing 90; primary anatomic site = missing 34; age = missing 31)]

*Face includes lip, nose, eyelid, and eye dermatitis

**Overall skin condition

	Primary Anatomic Site			Any of Up to 3 Anatomic Sites		
	APS-positive, Patient No. (%) N=192*	APS-negative, Patient No. (%) N=10,299*	APS-positive vs. APS-negative OR (95% CI), <i>p</i> -value	APS-positive, Patient No. (%) N=327	APS-negative, Patient No. (%) N=16,388	APS-positive vs. APS-negative OR (95% CI), <i>P</i> -value
Hand	58 (30.2)	2262 (22.0)	1.54 (1.13-2.10), <i>P</i> =0.0064	61 (18.7)	2679 (16.4)	1.17 (0.88-1.56), <i>P</i> =0.2645
Scattered generalized	49 (25.5)	1842 (17.9)	1.57 (1.14-2.18), <i>P</i> =0.0064	70 (21.4)	2475 (15.1)	1.53 (1.17-2.00), <i>P</i> =0.0017
Face	42 (21.9)	3354 (32.6)	0.58 (0.41-0.81), <i>P</i> =0.0017	66 (20.2)	4597 (28.1)	0.65 (0.49-0.85), <i>P</i> =0.0017
Face, NOS ⁺	23 (12.0)	1715 (16.7)	0.68 (0.43-1.04), <i>P</i> =0.0844	39 (11.9)	2410 (14.7)	0.79 (0.56-1.10), <i>P</i> =0.1593
Eyelids	14 (7.3)	1078 (10.5)	0.67 (0.39-1.14), <i>P</i> =0.1534	15 (4.6)	1370 (8.4)	0.53 (0.31-0.87), <i>P</i> =0.0143
Lips	5 (2.6)	520 (5.1)	0.50 (0.22-1.12), <i>P</i> =0.1237	10 (3.1)	712 (4.3)	0.69 (0.36-1.29), <i>P</i> =0.2572
Trunk	17 (8.9)	504 (4.9)	1.89 (1.16-3.09), <i>P</i> =0.0123	30 (9.2)	1196 (7.3)	1.28 (0.88-1.86), <i>P</i> =0.1975
Scalp	6 (3.1)	409 (4.0)	0.78 (0.37-1.70), <i>P</i> =0.5511	14 (4.3)	692 (4.2)	1.02 (0.59-1.73), <i>P</i> =0.9583
Arm	5 (2.6)	402 (3.9)	0.66 (0.29-1.57), <i>P</i> =0.3557	35 (10.7)	1282 (7.8)	1.41 (0.98-1.99), <i>P</i> =0.0556
Leg	4 (2.1)	345 (3.3)	---	19 (5.8)	913 (5.6)	1.05 (0.66-1.66), <i>P</i> =0.8519
Foot	3 (1.6)	220 (2.1)	---	12 (3.7)	526 (3.2)	1.15 (0.64-2.04), <i>P</i> =0.6407
Neck	---	201 (2.0)	---	9 (2.8)	938 (5.7)	0.47 (0.25-0.88), <i>P</i> =0.0214
Other	8 (4.2)	801 (7.8)	0.52 (0.25-1.0), <i>P</i> =0.0631	13 (4.0)	1195 (7.3)	0.53 (0.30-0.90), <i>P</i> =0.0218

Table 3. Anatomic Sites of Dermatitis

*Data missing: [Primary anatomic site: APS-positive = missing one; APS-negative = missing 34]

⁺NOS, not otherwise specified

	No. (%) N=193
Strength⁺	
Weak (+)	101 (52.3)
Strong (++)	52 (26.9)
Extreme (+++)	32 (16.6)
Doubtful (+/-)	8 (4.2)
Clinical Relevance[‡]	
Current	110 (57.0)
Definite	2 (1.0)
Probable	40 (20.7)
Possible	68 (35.2)
Past	37 (19.2)
Unknown	46 (23.8)

Table 4. Characteristics of Positive Reactions to Ammonium Persulfate

*APS, ammonium persulfate

⁺Final clinical assessment readings: weak (+) = non-vesicular reaction with erythema; strong (++) = edematous or vesicular reaction; extreme (+++) = bullous, spreading, and/or ulcerative reaction; doubtful (+/-) = macular erythema only

[‡]Clinical relevance definitions: (1) definite = positive patch or use test to putative item containing ammonium persulfate; (2) probable = positive patch or use test and ammonium persulfate found in item being used; (3) possible = skin contact with ammonium persulfate is likely to occur; (4) past = ammonium persulfate not in patient's current environment or applied to affected body site.

Pool/Spa Treatment		Hair Color/Lighteners	
Product Name	Alternative Base-ingredient	Product Name	Alternative Base-ingredient
Aqua Silk Chlorine-Free Shock Oxidizer	Hydrogen peroxide	L’Oreal Paris Colorist Secrets Brass Banisher	Hydrogen peroxide
Bacquacil Oxidizer	Hydrogen peroxide	Clairol Natural Instincts	Hydrogen peroxide
Pro Products Neutra Sul Professional Grade Oxidizer	Hydrogen peroxide	Biolage Plant-Based, No-Lift Ammonia Free Vegan Hair Color	---
Bioguard® SoftSwim Clarifier	Hydrogen Peroxide	Garnier Olia Ammonia Free Hair Color—Lightest Ash Blonde	Hydrogen peroxide
Aqua Silk Chlorine-Free Sanitizer	Biguanide	L’Oreal Superior Preference Fade-Defying Shine Permanent Hair Color	Hydrogen peroxide
SoftSoak By SpaGuard Sanitizer	Biguanide	L’Oreal Paris Ferie Very Light Natural Blonde	Hydrogen peroxide
HydroTech® Aquabrome®	Brominated	L’Oreal Paris Couleur Experte—Iced Meringue	Hydrogen peroxide
Poolife® Turboshock™ Shock Treatment	Hypochlorite		
DryTec Extra Shock	Hypochlorite		
Kem-Tek Pool & Spa Care Chlorinating Liquid for Pools	Hypochlorite		
Proguard Calcium Hypochlorite Granular	Hypochlorite		
Pool Time® All-In-One MaxBlue Chlorinating Granules	Trichloro-s-triazinetriene Boron sodium oxide		
Spa Time Dual-Purpose Sanitizer & Shock	Sodium dichloro-s-triazinetriene dihydrate		
Leisure Time Brominating Granular	Sodium dichloro-s-triazinetriene dihydrate Sodium bromide		

Table 5. Persulfate-Free Pool/Spa and Hair Bleaches/Lightener Products

Capsule Summary:

- Historically, allergy to ammonium persulfate has been associated with hair bleaching agents, especially in hairdressers.
- In this retrospective review of 10,526 routinely patch-tested patients, 193 (1.8%) had positive patch test reactions to ammonium persulfate. Males had a significant higher frequency of positivity and hot tub/pool exposures were common.