

IN-DEPTH REVIEW

Allergens Causing Allergic Contact Dermatitis in Cosmetic Products: A Systematic Review

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ABSTRACT

Background: The increasing use of cosmetics worldwide has led to a rise in allergic reactions, particularly due to inadequate risk assessment. Identifying common allergens in cosmetic products causing dermatitis is crucial for effective prevention and management strategies.

Objectives: This systematic review aims to determine the list of allergens that most commonly cause allergic contact dermatitis in cosmetic products and to find the patch test positivity rate for cosmetic products.

Methods: This systematic review, following the PRISMA guidelines, investigated patch test results on cosmetic-induced contact dermatitis from January 2013 to September 2023 on PubMed, Cochrane, and Medline databases. Inclusion criteria comprised retrospective cohort and clinical trial studies reporting patch test positivity rates and positive allergens in cosmetics, with eligibility determined through independent screening, full-text evaluation, and data extraction. Exclusion criteria comprised abstract-only publications, non-English or Indonesian languages, review articles, and studies with incomplete text.

Result: 13 studies were included out of 2,162 initially screened articles, involving 111,097 participants. The selected studies encompassed ten retrospective studies, and three clinical trials conducted in various locations, including India, Brazil, North America, Korea, Sweden, and the Czech Republic. The patch test positivity rate ranged from 13% to 100%. The predominant allergens identified in cosmetics were nickel sulfate, fragrance mix I, cobalt chloride, para-phenylenediamine base, potassium dichromate, and balsam of Peru.

Conclusion: This systematic review highlights the diversity in patch test positivity rates and identifies key allergens responsible for allergic contact dermatitis in cosmetic products, emphasizing the need for comprehensive evaluation and awareness of cosmetic safety.

INTRODUCTION

Cosmetics are materials or preparations applied to the skin, mouth, hair and nails for cleaning, beautifying the appearance, providing a pleasant aroma, or providing

protection without affecting the structure and function of the body. The ingredients or preparations included in cosmetics include perfume, deodorant, lipstick, moisturizer, hair dye, nail varnishes, mascara, eye shadow, sunscreen, soap, shampoo, and toothpaste.^{1,2} Nowadays, the development of

the cosmetics industry has resulted in high cosmetic consumption behavior. In Europe, allergic reactions to cosmetics are increasing due to inadequate pre-sale risk assessment trials.³⁻⁵ Subsequently, it is estimated that 95% of the female population uses cosmetics regularly every day, and at least 1-3% of the female population is allergic to cosmetics.^{1,6}

The patch test is an examination to confirm the presence of allergies and identify allergens that cause contact dermatitis in cosmetics.⁷ This is done by exposing individuals with allergic symptoms to various allergens that cause skin reactions.⁸ Patch tests with standard allergens can detect allergens in almost 70-80% of contact dermatitis cases.⁹ In extensive lesions, patch tests are not recommended for contact dermatitis testing.^{10,11} Previous studies show that the most common allergens that cause allergic contact dermatitis in cosmetics include nickel sulfate, preservatives methylisothiazolinone, formaldehyde, and p-phenylenediamine, as well as several fragrance ingredients such as balsam of Peru and fragrance-mix.² Subsequently, retrospective data collected on patch test patients in Europe in 2013-2014 by the European Surveillance System on Contact Allergies (ESSCA) shows that nickel is the allergen with the highest frequency of positive reactions.¹²

This systematic review aims to determine the list of allergens that most commonly cause allergic contact dermatitis in cosmetic products and to find the patch test positivity rate for cosmetic products.

METHODS

Study Design

This systematic review uses the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) approach. A search was conducted for studies of patch test results on contact dermatitis due to cosmetics from January 2013 to September 2023, with the following keywords: "patch testing" "cosmetic" dermatitis OR patch test "cosmetic" dermatitis OR "patch test" "cosmetic dermatitis" OR patch test on "cosmetic dermatitis" OR patch test on cosmetic dermatitis. The search strategy used the PubMed, Cochrane and Medline databases. All keywords used to search for articles in each database are presented in **Table 1**.

Eligibility Criteria

The next step was to establish the inclusion and exclusion criteria. In this study, the articles included met the inclusion criteria, including the type of study (retrospective cohort, clinical trial, and case-report study) and reported results (positivity rate patch test, positive allergens in cosmetic products). Subsequently, exclusion criteria are articles with incomplete text and languages other than Indonesian and English, review articles or non-original research. Furthermore, studies involving non-human subjects, non-peer-reviewed sources, duplicate publications, and those lacking sufficient data were also excluded.

Selection Process

TO and SW independently screened titles and abstracts to identify suitable studies during selection. Full-text papers were found and evaluated for eligibility using the inclusion and exclusion criteria. Any disagreements among the reviewers were handled through mutual discussion and then with the consensus of the third reviewer (HK).

Table 1. Medical Subject Heading (MeSH) terms used to search for articles in each database.

Database	MeSH Terms	Number of articles
PubMed	((((((((((("patch testing"[All Fields] AND "cosmetic"[All Fields]) AND ("dermatiti"[All Fields] OR "dermatitis"[MeSH Terms] OR "dermatitis"[All Fields] OR "dermatitides"[All Fields])) OR ("patch tests"[MeSH Terms] OR ("patch"[All Fields] AND "tests"[All Fields]) OR "patch tests"[All Fields] OR ("patch"[All Fields] AND "test"[All Fields]) OR "patch test"[All Fields])) AND "cosmetic"[All Fields]) AND ("dermatiti"[All Fields] OR "dermatitis"[MeSH Terms] OR "dermatitis"[All Fields] OR "dermatitides"[All Fields])) OR "patch test"[All Fields]) AND "cosmetic dermatitis"[All Fields]) OR ("patch tests"[MeSH Terms] OR ("patch"[All Fields] AND "tests"[All Fields]) OR "patch tests"[All Fields] OR ("patch"[All Fields] AND "test"[All Fields]) OR "patch test"[All Fields])) AND "cosmetic dermatitis"[All Fields]) OR (("patch tests"[MeSH Terms] OR ("patch"[All Fields] AND "tests"[All Fields]) OR "patch tests"[All Fields] OR ("patch"[All Fields] AND "test"[All Fields]) OR "patch test"[All Fields]) AND ("cosmetical"[All Fields] OR "cosmetically"[All Fields] OR "cosmetics"[Pharmacological Action] OR "cosmetics"[MeSH Terms] OR "cosmetics"[All Fields] OR "cosmetic"[All Fields]) AND ("dermatiti"[All Fields] OR "dermatitis"[MeSH Terms] OR "dermatitis"[All Fields] OR "dermatitides"[All Fields]))	2162
Cochrane Database	"patch test" AND "cosmetics"	52
Medline	"patch test" AND "cosmetics"	43

Data Extraction

Data extraction and study search results were obtained by taking information from studies, including author and year of publication, study design, study location, number of subjects, patch test positivity rate, allergen results, and cosmetic products discussed in the study. Next, the findings in the studies were recorded via Microsoft Excel and the three most common allergens that cause allergic contact dermatitis in cosmetic products were taken from each article. Two reviewers (TO and SW) independently extracted data. Any disagreements among the reviewers were handled through mutual

discussion and then with the consensus of the third reviewer (HK).

RESULTS

Study Selection

From the search results, a total of 2,257 articles were found in the initial search from three databases, namely PubMed 2,162 articles, Cochrane 52 articles and Medline 43 articles, then the articles were discarded after eliminating 95 duplicate articles. A total of 2,162 articles were screened, and 2,067 were excluded based on title, abstract and

year of publication. Ninety-three articles were assessed for eligibility, and 13 studies were included in the systematic review (**Figure 1**).

Study Characteristics

The studies selected in this systematic review consisted of 10 retrospective studies and three clinical trials. The study location was in India, four studies; Brazil and North America, three studies each; and Korea, Sweden, Czech Republic, one study each. The study subjects in this systematic review totaled 111,097 who were patch-tested on cosmetic products in the form of hair dye, fragrance/perfume, nail varnish, soap, shampoo, deodorant, hair care products, moisturizing cream, henna tattoos, traditional perfume, foundation, kumkum/bindi, sunscreen, eye care products, lip care products and makeup. The patch test positivity rate ranges from 13%-100% based on the type of study used (**Table 2**).

Allergens Causing Allergic Contact Dermatitis in Cosmetic Products

In this review, the allergens most commonly found in cosmetic products were nickel sulfate and fragrance mix I (six studies), cobalt chloride (four studies), parafenylenediamine base, potassium dichromate and balsam of Peru (three studies) (**Table 3**).

DISCUSSION

Cosmetics are substances or preparations used on the outside of the body for the specific purpose of cleaning, beautifying, increasing attractiveness and changing appearance without affecting the structure or function of the body.¹ Women, on average, use around 12 cosmetic products per day, which can contain up to 168 different

components, while men use six cosmetic products with a maximum of 85 ingredients.² The prevalence of cosmetic ingredient contact dermatitis is more common in women aged 20 to 55 due to the use of cosmetics and care products.¹²

Patch testing is a method used to identify the internationally defined causative agent of allergic contact dermatitis.¹³ Repeat exposure to the same allergen or hapten results in activation of hapten-specific T cells, which results in marked signs of hypersensitivity 48-72 hours after exposure to the allergen or hapten.¹⁴ Sensitized individuals have antigen-specific T lymphocytes that cause a reaction when the antigen is exposed to the skin due to previous sensitization.¹⁴ Indications for patch testing are patients with a differential diagnosis of contact dermatitis, patients with other skin conditions that may be aggravated by contact dermatitis, patients with chronic eczema of unknown aetiology and suspected cases of occupational contact dermatitis.¹⁴

The positivity rate of the patch test in this study was wide, ranging from 13-100%. This wide positivity rate is thought to be due to the small number of patients in some studies and the geographical factors of each country where the included studies were conducted. In this study, the patch test locations to determine allergens in allergic contact dermatitis due to cosmetics mainly were carried out in India with four studies, Brazil and North America with three studies each and in Korea, Sweden and Czechia with 1 study each.^{13,15-17,14,18,19,20-22} The common cultural use of 'Henna' and 'Binti' in Indian women causes IgE-mediated hypersensitivity reactions and contact dermatitis.²³ The active ingredient of henna is lawone (2-hydroxy-1, 4-naphthoquinone), which comes from the leaves and flowers of *Lawsonia inermis*, family Lythraceae, which

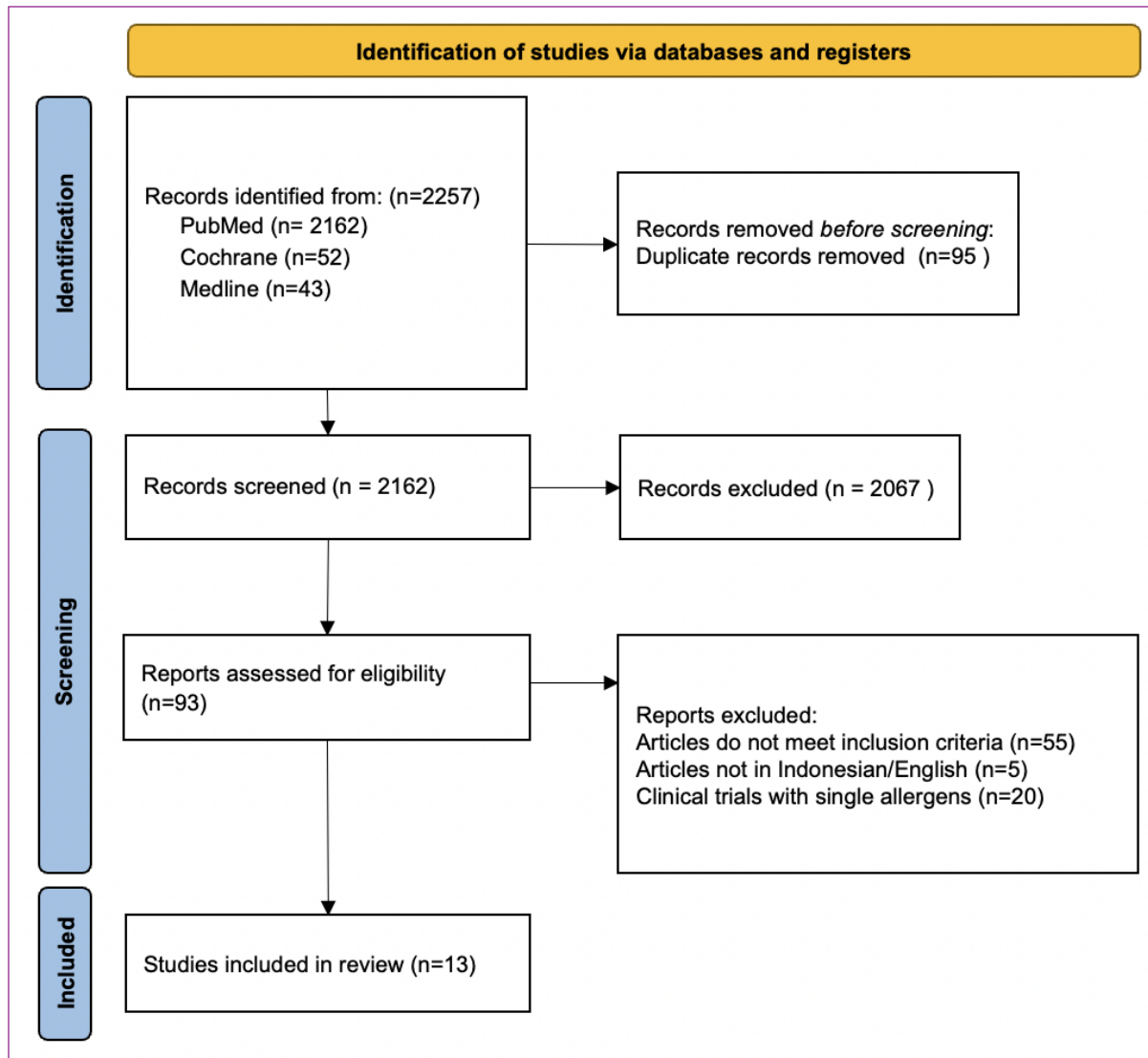


Figure 1. PRISMA diagram in this systematic review

grows in hot climates in north and west Africa and South Asia.²⁴ Natural henna ingredients rarely cause allergic reactions; most cases of allergic reactions are caused by para-phenylenediamine (PPD) ("black henna") dyes, diaminotoluene, and diaminobenzenes which are added to pure henna and aim to speed up the drying of the henna and strengthen the colour of the henna.²³

This study shows that the most common allergens that cause allergic contact dermatitis in cosmetics are nickel sulfate metal, fragrance-mix fragrances and

preservatives such as methylisothiazolinone and formaldehyde.^{13–15,25,26} The active ingredient para-phenylenediamine (DPD) in hair dye is a common allergen in cosmetics that causes contact dermatitis.²⁷ Fragrance ingredients such as fragrance-mix, balsam of Peru and colophony, as well as emulsifying ingredients such as lanolin, amerchol L-101 and propylene glycol, are also common allergens in cosmetics that cause contact dermatitis.^{15,16,26–28}

The most common allergen mentioned in the study was nickel sulfate^{13,15,19,20,25,26} and

Table 2. Study Characteristics

No	Author	Study Design	Location of Study	Number of Subjects	Positivity rate	Allergens	Cosmetic Products
1	Lee et al. (2016)	Clinical trials	Korea	27	100%	Para-phenylenediamine base (100%); Nickel sulfate (26.10%); and Cobalt chloride (17.40%)	Hair dye
2	Sadagopan et al. (2017)	Retrospective study	India	358	43.85%	Potassium dichromate, Nickel sulfate, and Cobalt chloride	Hair dye, cosmetic cream
3	Sukakul et al. (2022)	Retrospective study	Sweden	3663	13.10%	Fragrance-mix I (48%) and Fragrance-mix II (17%)	Fragrance
4	Tichy et al. (2015)	Retrospective study	Czech Republic	1941	-	Nickel sulfate (15.40%); Balsam of Peru (11.60%); and Fragrance-mix I (7.10%)	Perfume
5	Hafner et al. (2020)	Retrospective study	Brazil	403	57.50%	R-TSF (29.70%); Para-phenylenediamine base (26.30%); and Kathon (21%)	Nail colour, hair colour, fragrance/perfume, shampoo, hair care products, moisturizing cream, soap, sunscreen, deodorant
6	Hasan et al. (2017)	Retrospective study	North America	582	30%	Nickel sulfate, Potassium dichromate, and Cobalt chloride	Skin care products, hair dye, henna tattoos
7	Silva et al. (2020)	Retrospective study	Brazil	267	69.50%	Nickel sulfate (56.25%), Cobalt chloride (23.43%), and Neomycin sulfate (18.22%)	Cosmetic

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8	Majid et al. (2014)	Retrospective study	India	550	41.45%	Nickel sulfate (29.30%); Potassium dichromate (21.40%); and Fragrance-mix I (19.95%)	Traditional cosmetics and perfume
9	Figueiredo et al. (2018)	Retrospective study	Brazil	1870	13.80%	Fragrance-mix I (70.90%); Balsam of Peru (20.10%); and Colophony (32.30%)	Fragrance
10	Gupta et al. (2015)	Clinical trials	India	80	67.50%	Para-phenylenediamine, Fragrance-mix I, and Thiuram mix	Hair dye
11	Kumar et al. (2014)	Clinical trials	India	50	50%	Gallate mix (40%); Cetrimide (28%); and Thiomersal (20%)	Face cream, hair dye, shaving cream, perfume, nail colour, foundation, kumkum/bin di
12	Warshaw et al. (2020)	Retrospective study	North America	50507	-	Methylisothiazolinone (9.90%); Fragrance-mix I (8.50%); and Balsam of Peru (6.80%)	Personal care products (hair care, moisturizer, lotion, soap, perfume and fragrance, sunscreen, oral cleansing products, eye care products, lip care products and makeup)

13	Atwater et al. (2021)	Retrospective study	North America	50799	22.30%	Methylisothiazolinone (12.20%); Formaldehyde (7.80%); and Petrolatum (7.70%)	Cosmetic
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Table 3. The highest number of allergens found in the study

Allergen	Number of Studies
Fragrance-mix I and Nickel sulfate	6
Cobalt chloride	4
Para-phenylenediamine base, Potassium dichromate, and Balsam of Peru	3
Methylisothiazolinone	2
Formaldehyde; Gallate mix; Fragrance-mix II; R-TSF; Kathon; Neomycin sulfate; Colophony; Thiuram mix; Cetrimide; Thiomersal; and Petrolatum	1

fragrance-mix I.^{15,16,18,26,27,29} Other allergens found in this study include cobalt chloride, para-phenylenediamine base, potassium dichromate and balsam of Peru.^{11,30–36} Nickel sulfate is one of the most widely used metals in the world.³⁷ Nickel sulfate is the allergen with the highest prevalence of contact allergies and the most common positive hapten in patients undergoing patch testing for suspected contact dermatitis.¹⁴ Nickel ion is a potent allergen or hapten that can cause dermatitis.³⁷ Jewelry is the most common source of nickel allergy exposure and includes earrings, necklaces, medals, brooches, bracelets, watches and rings.² Cosmetics, especially pigmented mascara, eyeshadow, soap, and detergent, are examples of cosmetics that contain nickel.³⁸

The following most common allergen in this study was fragrance-mix I.^{15,16,26–28,39} Fragrance-mix I contains eugenol, isoeugenol, cinnamic alcohol, cinnamic aldehyde, amylcinnamaldehyde, geraniol, and hydroxytronellal.⁶ Fragrance-mix I includes many synthetic compounds in cologne, eau de toilette and aftershave.³⁸

Fragrance-mix I is also found in cosmetics for skin, nail, hair and eye care, toothpaste, sunscreen cream, and cleaning products for adults and children, including wet wipes and insect repellent.³⁸

Another allergen found in this review, cobalt chloride, was mentioned in four studies.^{13,19,20,25} Study by Reduta et al. in Poland in 2013 showed positive reactions to cobalt chloride, which occurred in 15.3% of people tested.⁴⁰ Cobalt is a heavy metal which has side effects in the form of nausea, vomiting, visual and heart problems and has carcinogenic side effects.³⁷ High concentrations of cobalt chloride in cosmetic ingredients such as henna, foundation, skin whitening cream, and eyeliner can increase the incidence of allergic contact dermatitis in patients.⁴¹

Para-phenylenediamine (PPD) or 1,4-phenylenediamine is an aromatic diamine that has a risk of irritation and is used as a colour-enhancing agent in hair dyes, temporary tattoos and henna.²⁴ Para-phenylenediamine (PPD) has been used in

hair dyes since the late 19th century and is a significant source of contact sensitization to the PPD allergen.^{24,42} A Study by Mukkana in England in 2017 involving patients with dermatitis due to PPD has shown a prevalence of positive patch tests for PPD material of 6.2% in North America, 4% in Europe, and 4.3% in Asia.⁴³

The following allergen found in this review is potassium dichromate or chromium dichromate, which is mentioned three times.^{13,15,20} Potassium dichromate is widely used in daily activities and is found in many bleaching agents, detergents, cement, implants, prostheses, cell phones and cosmetics such as eye shadows.⁴⁴ In Europe, the use of chromium has been banned since 1976, but the use of chromium metal in small quantities is still permitted.⁴⁴ Small amounts of chromium in cosmetics do not pose a significant risk of chromium carcinogenic effects but can potentially cause contact dermatitis.⁴⁴

Balsam of Peru allergens were mentioned in 3 studies in this review.^{26,28,39} Balsam of Peru is a tree resin derived from *Myroxylon pereirae*.²⁸ Balsam of Peru is a fragrance ingredient containing benzyl cinnamate and benzyl benzoate, which can cause skin rashes in allergic individuals.⁴⁵ This resin's characteristic sweet and vanilla aroma consists of various fragrance components, and it is estimated that almost 50% of patients with fragrance allergies will react to this allergen.²⁶ Balsam of Peru is often found in perfumes, colognes, air fresheners, scented candles, cosmetics, oral cleaning, hair care, pet care, and household cleaners.⁴⁵

Methylchloroisothiazolinone/methylisothiazolinone (MCI/MI) is one of the most widely used preservatives in industrial, cosmetic, and household products.^{22,28}

Methylchloroisothiazolinone can be found in products such as detergent, shampoo, conditioner, cleansing wipes, make-up remover, face and body cream, deodorant, foundation, mascara, eye shadow, colour, and sunscreen.²² In 2017, the European committee set the maximum safe concentration of MCI/MI at 0.0015% (15 ppm) due to the increasing prevalence of sensitization to MI for cosmetic products.³⁸

Formaldehyde is an allergen commonly used as a preservative in cosmetics, household products, and industrial products.²² Formaldehyde can be found in cosmetic products such as facial cream, mascara, foundation, deodorant, shampoo, hair conditioner, toothpaste and topical antibiotics.³⁸ Currently, the incidence of sensitization due to formaldehyde has decreased due to the replacement of preservatives using safer formaldehyde-releasing agents.^{46,47}

Gallate is an alkyl ester of trihydroxy benzoic acid consisting of propyl gallate, octyl gallate and dodecyl gallate and is used as a preservative.¹⁷ Propyl gallate is the most common gallate chemical found in foods and personal care products.⁴⁸ Most cosmetic products contain propyl gallate, including lipstick, lip gloss and other products applied to the lips.⁴⁸ Cases of sensitization from gallate-containing substances are relatively rare, with an estimated incidence of 3.92%, due to increased oral tolerance after repeated exposure.⁴⁶

This study also has several limitations. First, a notable geographical bias is observed, with a concentration of studies in specific regions like India, Brazil, and North America. Furthermore, the preponderance of retrospective studies in the selected pool introduces inherent biases that could impact our systematic review's overall robustness

and reliability. Moreover, the diversity in cosmetic products tested presents a potential source of variability in allergen exposure. The sample size in clinical trials is also significantly lower than in retrospective studies, giving the possibility of selection bias that may not represent general population.

CONCLUSION

In conclusion, this systematic review contributes meaningful insights into the prevalence and allergen profiles of cosmetic-induced contact dermatitis. Identifying key allergens, such as nickel sulfate and fragrance mix I, emphasizes the importance of targeted interventions and increased awareness within the cosmetics industry. For future studies, a more comprehensive global representation and a mix of study designs are recommended to enhance the reliability of the conclusions drawn from such investigations.

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References:

- Garg T, Agarwal S, Chander R, Singh A, Yadav P. Patch testing in patients with suspected cosmetic dermatitis: A retrospective study. *J Cosmet Dermatol*. 2018;17(1):95-100.
- Alani JI, Davis MDP, Yiannias JA. Allergy to cosmetics: A literature review. *Dermatitis*. 2013;24(6):283-290.
- Schwensen JF, White IR, Thyssen JP, Menné T, Johansen JD. Failures in risk assessment and risk management for cosmetic preservatives in Europe and the impact on public health. *Contact Dermatitis*. 2015;73(3):133-141. doi:10.1111/cod.12446
- Lidén C, Andersson N, White IR. Preservatives in non-cosmetic products: Increasing human exposure requires action for protection of health. *Contact Dermatitis*. 2022;87(5):389-405. doi:10.1111/cod.14181
- Afridi HI, Ali A, Bhatti M, et al. Effect of Lead on the Skin and Health of Female Dermatitis Patients Through Cosmetics. *Journal of Ayub Medical College*. 2023;35(1):88-94. doi:10.55519/JAMC-01-11442
- Park ME, Zippin JH. Allergic contact dermatitis to cosmetics. *Dermatol Clin*. 2014;32(1):1-11.
- Johansen JD, Aalto-Korte K, Agner T, et al. European Society of Contact Dermatitis guideline for diagnostic patch testing - Recommendations on best practice. *Contact Dermatitis*. 2015;73(4):195-221. doi:10.1111/cod.12432
- Sedó-Mejía G, Soto-Rodríguez A, Pino-García C, Sanabria-Castro A, Monge-Ortega OP. Contact dermatitis: Clinical practice findings from a single tertiary referral hospital, a 4-Year retrospective study. *World Allergy Organization Journal*. 2020;13(7):100440. doi:10.1016/j.waojou.2020.100440
- Qin O, Cheng Y, Hu W, et al. Patch test in Chinese in Shanghai with cosmetic allergy to cosmetic series and products. *Journal of Cosmetic Dermatology*. 2020;19(8):2086-2092. doi:10.1111/jocd.13249
- Vigneshkarthik N, Ganguly S, Kuruvila S. Patch test as a diagnostic tool in hand eczema. *Journal of Clinical and Diagnostic Research*. 2016;10(11):WC04-WC07. doi:10.7860/JCDDR/2016/23994.8884
- Boonchai W, Iamtharachai P. Risk factors for common contact allergens and patch test results using a modified European baseline series in patients tested during between 2000 and 2009 at Siriraj Hospital. *Asian Pacific Journal of Allergy and Immunology*. 2014;32(1):60-65. doi:10.12932/AP0326.32.1.2014
- Chou M, Mikhaylov D, Strugar TL. Common allergens present in personal care products: identification, diagnosis, and management. *Review Semin Cutan Med Surg*. 2018;37(4):254-262.
- Sadagopan K, Kalappan D, Sivaprakasam N, Vinoth. Patch test results from an occupational and contact dermatitis clinic in a tertiary care hospital of southern India: A retrospective study. *Journal of Clinical and*

- Diagnostic Research*. 2017;11(8):WC11-WC14.
14. Hafner M de FS, Rodrigues AC, Lazzarini R. Allergic contact dermatitis to cosmetics: Retrospective analysis of a population subjected to patch tests between 2004 and 2017. *Anais Brasileiros de Dermatologia*. 2020;95(6):696-701. doi:10.1016/j.abd.2020.04.011
 15. Majid I. Contact allergens in Kashmiri population: Results from a 6-year patch testing experience in 550 patients. *Indian Journal of Dermatology, Venereology and Leprology*. 2014;80(1):62-64.
 16. Gupta M, Mahajan V, Mehta K, Chauhan P. Hair dye dermatitis and p-phenylenediamine contact sensitivity: A preliminary report. *Indian Dermatology Online Journal*. 2015;6(4):241.
 17. Kumar P, Paulose R. Patch testing in suspected allergic contact dermatitis to cosmetics. *Dermatology Research and Practice*. 2014;2014.
 18. Figueiredo M De, Hafner S, Daniele S, Munhoz G, Jeldes AG. Positive results of patch tests with fragrance markers: analysis of a 15- year period at a Brazilian dermatology center. *Anais Brasileiros de Dermatologia*. 2018;93(6):910-912.
 19. Silva EA, Bosco MRM, Lozano RR, Latini ACP, Souza VNB de. High rate of sensitization to Kathon CG, detected by patch tests in patients with suspected allergic contact dermatitis. *Anais Brasileiros de Dermatologia*. 2020;95(2):194-199. doi:10.1016/j.abd.2019.09.026
 20. An I, Harman M, Ibiloglu I. Clinicoepidemiological and Patch Test Profile of Patients Attending the Contact Dermatitis Clinic of a Tertiary Care Hospital in North India: A 7-Year Retrospective Study. *Indian Dermatology Online Journal*. 2017;10(4):481-485. doi:10.4103/idoj.IDOJ
 21. Warshaw EM, Schlarbaum JP, Maibach HI, et al. Facial Dermatitis in Male Patients Referred for Patch Testing. *JAMA Dermatology*. 2020;156(1):79. doi:10.1001/jamadermatol.2019.3531
 22. Atwater AR, Petty AJ, Liu B, et al. Contact dermatitis associated with preservatives: Retrospective analysis of North American Contact Dermatitis Group data, 1994 through 2016. *Journal of the American Academy of Dermatology*. 2021;84(4):965-976.
 23. Treister-Goltzman Y, Egbaria E, Peleg R. Images in clinical tropical medicine: An allergic reaction to henna used in a traditional painting ceremony. *American Journal of Tropical Medicine and Hygiene*. 2016;94(5):941.
 24. Gupta D, Thappa DM. Dermatoses due to Indian cultural practices. *Indian Journal of Dermatology*. 2015;60(1):3-12.
 25. Lee HJ, Kim WJ, Kim JY, et al. Patch tests with commercial hair dye products in patients with allergic contact dermatitis to para-phenylenediamine. *Indian Journal of Dermatology, Venereology and Leprology*. 2016;82(6):645-650.
 26. Tichy M, Karlova I. Allergic contact dermatitis and changes in the frequency of the causative allergens demonstrated with patch testing in 2008-2012. *Biomedical Papers*. 2015;159(3):480-488.
 27. Sukakul T, Bruze M, Mowitz M, et al. Simultaneous patch testing with fragrance markers in the baseline series and the ingredients of fragrance mixes: An update from southern Sweden. *Contact Dermatitis*. 2022;86(6):514-523.
 28. Warshaw EM, Schlarbaum JP, Maibach HI, et al. Facial Dermatitis in Male Patients Referred for Patch Testing: Retrospective Analysis of North American Contact Dermatitis Group Data, 1994 to 2016. *JAMA Dermatology*. 2020;156(1):79-84.
 29. Warshaw EM, Ruggiero JL, DeKoven JG, et al. Patch testing with ammonium persulfate: The North American Contact Dermatitis Group Experience, 2015-2018. *Journal of the American Academy of Dermatology*. 2022;87(5):1014-1023. doi:10.1016/j.jaad.2021.08.005
 30. Tagka A, Lambrou GI, Nicolaidou E, Gregoriou SG, Katsarou-Katsari A, Rigopoulos D. The Effect of Atopy in the Prevalence of Contact Sensitization: The Experience of a Greek Referral Center. *Dermatology Research and Practice*. 2020;2020. doi:10.1155/2020/3946084
 31. Rodrigues DF, Goulart EMA. Patch test results in children and adolescents. Study from the Santa Casa de Belo Horizonte Dermatology Clinic, Brazil, from 2003 to 2010. *Anais Brasileiros de Dermatologia*. 2015;90(5):671-683. doi:10.1590/abd1806-4841.20153902
 32. Dararattanaroj W, Pootongkam S, Rojanawatsirivej N, Wongpiyabovorn J. Patterns and risk factors of causative contact allergens in Thai adult patients with contact dermatitis. *Asian Pacific Journal of Allergy*

- and *Immunology*. 2017;35(1):27-32. doi:10.12932/AP0757
33. Tagka A, Lambrou GI, Matsopoulos GK, et al. Analysis of Prevalence and Risk Factors of Contact Sensitization with respect to the Occupational Profiles in a Greek Patient Cohort: A Retrospective Analysis of a Greek Referral Centre and Future Perspectives. *BioMed Research International*. 2021;2021. doi:10.1155/2021/6672506
 34. Uter W, Hallmann S, Gefeller O, et al. Contact allergy to ingredients of hair cosmetics in female hairdressers and female consumers—An update based on IVDK data 2013–2020. *Contact Dermatitis*. 2023;(February):161-170. doi:10.1111/cod.14363
 35. Kim DS, Bae JM, Jee H, et al. Analysis of contact allergens in Korean polysensitized patients by patch testing: A pilot study. *Acta Dermato-Venereologica*. 2014;94(1):80-81. doi:10.2340/00015555-1649
 36. Sundquist BK, Yang B, Pasha MA. Experience in patch testing: A 6-year retrospective review from a single academic allergy practice. *Annals of Allergy, Asthma and Immunology*. 2019;122(5):502-507. doi:10.1016/j.anai.2019.02.028
 37. Ullah H, Noreen S, Fozia, et al. Comparative study of heavy metals content in cosmetic products of different countries marketed in Khyber Pakhtunkhwa, Pakistan. *Arabian Journal of Chemistry*. 2017;10(1):10-18.
 38. Zirwas MJ. Contact dermatitis to cosmetics. *Clinical Reviews in Allergy and Immunology*. 2019;56(1):119-128.
 39. Figueiredo M De, Hafner S, Daniele S, Munhoz G, Jeldes AG. year period at a Brazilian dermatology center *. *Anais Brasileiros de Dermatologia*. 2018;93(6):910-912.
 40. Reduta T, Bacharewicz J, Pawłóś A. Patch test results in patients with allergic contact dermatitis in the Podlasie region. *Postepy Dermatologii i Alergologii*. 2013;30(6):350-357. doi:10.5114/pdia.2013.39433
 41. Iwegbue CMA, Basse FI, Obi G, Tesi GO, Martincigh BS. Concentrations and exposure risks of some metals in facial cosmetics in Nigeria. *Toxicology Reports*. 2016;3:464-472.
 42. Panfili E, Esposito S, Di Cara G. Temporary black henna tattoos and sensitization to para-phenylenediamine (PPD): Two paediatric case reports and a review of the literature. *International Journal of Environmental Research and Public Health*. 2017;14(4):1-8. doi:10.3390/ijerph14040421
 43. Mukkanna KS, Stone NM, Ingram JR. Para-phenylenediamine allergy: Current perspectives on diagnosis and management. *Journal of Asthma and Allergy*. 2017;10:9-15. doi:10.2147/JAA.S90265
 44. Bregnbak D, Johansen JD, Jellesen MS, Zachariae C, Menné T, Thyssen JP. Chromium allergy and dermatitis: Prevalence and main findings. *Contact Dermatitis*. 2015;73(5):261-280.
 45. Nanda A, Wasan A. Allergic contact dermatitis to balsam of Peru. *Annals of Allergy, Asthma and Immunology*. 2016;117(2):208-209.
 46. González-Muñoz P, Conde-Salazar L, Vañó-Galván S. Allergic contact dermatitis caused by cosmetic products. *Actas Dermo-Sifiliograficas*. 2014;105(9):822-832. doi:10.1016/j.adengl.2014.09.007
 47. Zukiewicz-Sobczak WA, Adamczuk P, Wroblewska P, et al. Allergy to selected cosmetic ingredients. *Postepy Dermatologii i Alergologii*. 2013;30(5):307-310. doi:10.5114/pdia.2013.38360
 48. Holcomb ZE, Van Noord MG, Atwater AR. Gallate contact dermatitis: Product update and systematic review. *Dermatitis*. 2017;28(2):115-127.