REVIEW ARTICLE

Aspects of Adverse Effects of Cosmetic Products: An Invited Narrative Review

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The use of cosmetic products is ubiquitous around the world. This article reviews the medical literature documenting adverse effects associated with cosmetic product use. An extensive, nonexhaustive literature search was conducted using the PubMed database. Studies reporting adverse effects from cosmetic products were included, encompassing case reports, case series, clinical trials and epidemiological studies. Contact dermatitis is the most common adverse effect associated with cosmetic use, affecting approximately 1–5% of the general population. Additional effects, including respiratory sensitization, photosensitization, workplace exposures and issues specific to pregnancy/lactation, are discussed. The clinical significance of these effects remains poorly understood, particularly regarding long-term exposure and cumulative health impacts. Cosmetic usage can result in a spectrum of adverse effects that represent significant clinical and public health concerns.

Key words: cosmetics; adverse effects; contact dermatitis; allergens; safety assessment.

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SIGNIFICANCE

Cosmetics are integral to daily life. The global cosmetics industry is rapidly expanding, continuously introducing new products for consumer use. This growth necessitates rigorous safety oversight, as cosmetic products are associated with a range of adverse effects, from mild skin irritation to respiratory sensitization, workplace exposures and chronic disease. Comprehensive evaluation is essential to accurately assess their health impacts.

According to regulation (EC) No 1223/2009 of the European Parliament, a "'cosmetic product' means any substance or mixture intended to be placed in contact with the external parts of the human body (epidermis, hair system, nails, lips and external genital organs) or with the teeth/mucous membranes of the oral cavity" with a goal of cleaning/perfuming, changing appearance and protection (1). The global cosmetics industry has developed into a multi-billion-dollar sector, with a market size estimated at USD 335.95 billion in 2024. On average, men use approximately six products and women use 16 products daily (2). The market is projected to increase from USD 354.68 billion in 2025 to USD 556.21 billion by 2032 (3). This expansion is driven by rising demand for a wide range of products, from traditional skincare formulations to advanced cosmeceuticals containing pharmaceutical-grade active ingredients.

Cosmetic products are not subject to the rigorous premarket safety testing required for pharmaceutical products, often relying instead on manufacturer responsibility and postmarket surveillance. Consequently, the adverse effects of certain cosmetic products may not declare themselves until they have been used en masse by consumers. A wide range of adverse effects exist, harbouring varying levels of harm to consumer health that must be investigated thoroughly and subject to proper oversight.

METHODS

An extensive, nonexhaustive literature search was conducted using the PubMed database. Studies reporting adverse effects from cosmetic products were evaluated by both authors and relevant articles were included, encompassing case reports, case series, clinical trials and epidemiological studies.

International regulatory frameworks

Currently, there is no centralized regulatory framework for cosmetic products and regulation varies significantly. Some of the most well-established frameworks include the European Union's Cosmetic Regulation (EC 1223/2009) and the United States' Modernization of Cosmetics Regulation Act, with other countries having similar directives. In 2007, the International Cooperation on Cosmetics Regulation was organized to open dialogue surrounding cosmetic

regulation. Cosmetic industry associations are allowed to participate, allowing for channels of communication between regulators and manufacturers. In the years since its inception, more countries have shown interest in participation which will hopefully foster further global cooperation in this area (4).

The EU's current framework was designed to be readily applicable to all member states while reflecting updates in safety data. For monitoring, it generally does not require premarket certification of products but rather a notification to a centralized portal. Exceptions to this include ingredients such as preservatives, colourants and UV filters, among others, which undergo specialized premarket approval by the Scientific Committee on Consumer Safety. Manufacturers shoulder responsibility for compliance and they must keep a safety assessor reviewed product information file that should be kept ready for inspection by authorities. Notably, the EU has implemented a ban on all animal testing for cosmetics, leaving an opening in safety data testing. In its stead, nonanimal models (NAM) such as *in vitro* cell-based models, human tissue models and *in silico* computational models have emerged as promising alternatives (5, 6). Compared to animal models, certain NAM have demonstrated increased predictivity due to use of human or human equivalent tissue as opposed to animal tissue (7). NAM continue to be developed, which could further replace animal models in global markets with an ethical and reliable alternative.

The EU has also banned and restricted thousands of ingredients that carry mutagenic, carcinogenic and toxic concerns. Postmarket surveillance mandates reporting of adverse events to authorities, who then inform the manufacturer and wider EU (1).

The introduction of the Modernization of Cosmetics Regulation Act (MoCRA) in 2022 ushered in a wave of regulatory changes in the USA. Prior to 2022, the FDA did not explicitly set a safety standard for cosmetic products, contrasting with its regulation of other products such as food which required a "reasonable certainty of no harm." Now cosmetics have been brought to the same standard and no specific tests are required to substantiate product safety. However, manufacturers are responsible for presenting scientifically robust data that supports safety. They are also required to follow good manufacturing practices and register their facilities every 2 years to ensure continued adherence to standards. If a product is deemed misbranded or adulterated, the FDA holds the right to mandatory recall if the responsible manufacturer refuses recall, which previously relied on voluntary cooperation. The MoCRA prohibits or restricts only 11 ingredients commonly found in cosmetics as the US has espoused a more market-driven approach allowing more manufacturing liberties and relying on postmarket surveillance to uncover adverse effects. To that end, companies are now responsible for the reporting of adverse events, creating a cosmetovigilance system similar to those in other countries (8).

Contact dermatitis: The predominant adverse effect

The most frequently encountered adverse effects of cosmetic products are cutaneous reactions with contact dermatitis (CD) being the most common. Published data estimates that CD accounts for 84.3% of cosmetic adverse reactions (9). CD can be divided into either irritant or allergic contact dermatitis. In general, irritant contact dermatitis (ICD) accounts for ~80% of CD while allergic contact dermatitis (ACD) accounts for the remaining 20% (10). The true rates of cosmetic induced ICD and ACD remain nebulous. Women are much more likely than men to experience cosmetic related dermatitis, with one study finding adolescent females were three times more likely to experience dermatitis than their male counterparts (11). Adolescents and young adults appear to face an increased risk of CD due to more frequent exposure to cosmetic products while cumulative exposure to cosmetic sensitizers renders middle-aged and older populations more susceptible to contact allergy. Middle-aged adults have the highest rate of positive patch tests, with older adults having similar rates (12, 13). Overall, rates of CD to personal care products (PCPs), which includes many cosmetics, have risen more than 2.7-fold from 1996 to 2016 (14). Cosmetic associated CD requires more in depth investigation and analysis to ensure consumer protection.

Irritant contact dermatitis

ICD is caused by an exogenous substance contacting the skin, leading to inflammation and skin barrier disruption. Thought previously to be entirely non-immunological, the skin barrier disruption in ICD results in increased permeability of irritants which causes immune activation and an inflammatory response at the site of irritation (15). The most common causes include water, soaps, detergents, hand sanitizers, solvents and sweat.

In cosmetics, microbial growth presents a health risk to consumers, thus preservatives are widely added for their antimicrobial and antioxidant properties. However, they possess irritant and allergic side-effects. The preservative benzalkonium chloride (BAK) is a well-known irritant. Müller-Decker et al. found that application of BAK led to erythema, increased trans-epidermal water loss, and increased levels of eicosanoids in suction blister fluid, providing strong evidence of an inflammatory response (16).

Surfactants are effective cleaning agents that help eliminate skin debris including dirt, sebum and oil. Through their ability to solubilize membrane lipids and

denature proteins, they can disrupt the stratum corneum, increase membrane permeability and lead to irritation and inflammation (17). Anionic surfactants, including sodium lauryl sulfate (SLS), sodium laureth sulfate and TEA-lauryl sulfate, are known to be potent irritants. Amphoteric surfactants such as cocamidopropyl betaine are minimally irritating compared to other surfactants and are thus more frequently used in baby and gentle shampoos (18).

Ingredients causing ICD are contained across almost all categories of cosmetics and complete avoidance by consumers is likely impractical. Avoiding preservatives and surfactants with documented high irritancy should be a priority for consumers and manufacturers alike.

Allergic contact dermatitis

Allergic contact dermatitis (ACD) involves type IV hypersensitivity reactions mediated by T-lymphocytes following sensitization to specific cosmetic allergens (19). Every product used on the skin has the potential to sensitize and then subsequently drive ACD. Common haptens are fragrance components, preservatives, surfactants, hair colouring agents, metals and plant-derived botanical ingredients.

Identification and avoidance of the individual patient's unique spectrum of haptens is of the utmost importance for treating ACD and subsequently maintaining minimal symptom relapse. Ingredients with documented elevated risk for contact sensitization potential should be subject to more stringent regulations. This has shown benefit as regulatory efforts in the EU have decreased the incidence of contact dermatitis by identifying and restricting the usage of potent contact allergens (20). Studies that have identified recent trends and emerging allergens in the marketplace should not be ignored to prevent contact dermatitis epidemics akin to the widespread ACD caused by MI/MCI. Patch testing remains the gold standard for identification of contact allergy and healthcare providers should have low thresholds for extended series testing when clinically relevant and standard screening yields equivocal results.

Fragrances

Fragrance ingredients are ubiquitous in the cosmetic world, being found in virtually all categories of products. Their use ranges from purposefully imparting a pleasant scent to helping mask unpleasant odors of products. Many of these ingredients are well documented drivers of ACD and for patients with fragrance induced ACD, the primary exposure often comes from cosmetic use.

Accordingly, fragrances are included in standard patch testing series. In 2,044 commercially available products, the most frequently encountered fragrance allergens were limonene, linalool and benzyl alcohol (21). Bennike et al. evaluated ingredients specifically in fragranced cosmetics and found linalool and limonene were in 49.5% and 48.5% of products, respectively (22). Unfortunately, limonene and linalool are not reliably screened with the baseline fragrance screening allergens. 38% of patients would have had missed fragrance positives had they not been tested specifically with limonene and linalool (23). To reflect this, the American Contact Dermatitis Society updated their baseline series to include hydroperoxides of limonene and linalool in 2020, though not all screening series adequately assess for limonene and linalool allergy (24).

Of note, labelling of fragrance ingredients in the US is not as stringent as in the EU due to the Fair Packaging and Labeling Act. Manufacturers are not required to disclose individual fragrance ingredients. Rather, products simply need to list "fragrance" or "flavour" for sufficient adherence (25). In the EU, 80 fragrance allergens are required to be individually labeled if present at more than 10 ppm in leave-on and 100 ppm in wash-off products (26). In a survey of fragranced products, many required ingredients were improperly labelled, leading to consumers unknowingly being exposed to fragrances (22). Targeted fragrance avoidance often proves difficult for patients, and they are often advised to eliminate it completely.

Botanical ingredients

Botanicals are plant derived substances whose use is increasing across various categories of cosmetic products. More products are being marketed as "all-natural," putting forth that their formulations do not contain artificial ingredients. Inclusion of natural ingredients does not necessarily equate to increased safety; haphazard selection of untested natural products to replace well-established ingredients may lead to cutaneous reactions. Of 122 patients patch tested with a botanical series, 16% showed positive reactions, with the most common contact allergens being propolis, Compositae extracts and tea tree oil (27). Another study reported that of 15,980 patients, 125 (0.8%) positive reactions were due to topical herbal remedies. Balsam Peru, Compositae plants, tincture of benzoin, tea tree oil and propolis were the common allergens (28). Analysis of data from 2010 to 2019 also demonstrated that a variety of essential oils, highly concentrated plant extracts, yielded positive patch tests in 8.3% of patients. The most frequent reactions occurred to ylang-ylang, lemongrass, jasmine absolute, sandalwood, clove and neroli oil (29).

Preservatives

Preservative agents prevent microbial contamination and extend the shelf life of cosmetic products;

however, they remain among the most frequently encountered sensitizers. From 2009 to 2012, MI had the highest sensitization rate among preservative agents with a prevalence of 4.5%. MI/MCI followed closely behind at 4.1%. Parabens and formaldehyde releasers had prevalences of less than 1% (30). More recent trends of preservative contact allergy found the most commonly positive allergens upon patch testing were MI (3.5%), MI/MCI (3.2%), benzisothiazolinone (BIT) (2.1%), methyldibromoglutaronitrile (MDBGN) (2.5%), formaldehyde (2.2%) and formaldehyde releasers (1.2%) (31). Encouragingly, the prevalence of MI contact allergy has decreased 50% due to implementation of more stringent EU regulations in 2017 and 2018 (20). The most prevalent preservatives in products are not the same as the most commonly found patch test reactions. The most common preservatives in products were methylparaben (41%), phenoxyethanol (39%), sodium benzoate (34%), propylparaben (25%) and methylisothiazolinone/methylchloroisothiazolinone (MI/MCI) (22%). At least one formaldehyde releaser was found in 25% of products (32).

This discrepancy in prevalence in products compared to positivity rates supports that some allergens are likely stronger sensitizers than others. Phenoxyethanol, parabens and benzyl alcohol have been found to have relatively low rates of sensitization relative to the frequency of inclusion in products. Schnuch et al. reported that phenoxyethanol had little to no risk of sensitization. Benzyl alcohol and parabens exhibited similar low risk. Benzoates, the formaldehyde releasers imidazolidinyl and diazolidinyl urea as well as MI showed moderate risk of sensitization when calculated according to the authors' sensitization exposure quotient. MI/MCI was one of the most high-risk potential contact allergens, second only to 2-bromo-2-nitropropane-1,3-diol (Bronopol) (33).

Acrylates

Acrylates allergy is most often derived from diverse sources such as manufacturing and cosmetic exposures through acrylic nail systems (34). Artificial nail modelling systems (ANMS) have become more prevalent in beauty establishments and the greater cosmetic market. Hilewitz et al. found that 8.1% of participants had positive patch test reactions to 2-Hydroxyethyl methacrylate (HEMA), the majority of which were attributable to nail cosmetics (35). The stereotypical presentation of acrylate ACD is ectopic dermatitis on the eyelids but also may present as localized dermatitis around the nails or nail dystrophy.

The prevalence of females to males with positive tests was 11% to 1% and women under 30 were the most affected demographic. They also noted that the rate of acrylate allergy increased due to COVID-19 restrictions and higher home cosmetic nail use. Outside of strict consumer use, occupational exposures exist as well; another study found acrylates to be the most common source of ACD in beauticians and to be increasing in incidence from 1996 to 2011 (36). Nearly 90% of respondents to a Danish survey of hairdressers reported self-use of ANMS and 22.1% reported applying them to others (37). HEMA is a significant contributor to acrylate ACD and has been found to be responsible for up to 97% of acrylate contact allergy (38). Despite this, in a study of over 2,000 patients, 20.3% of acrylate positive patients did not react to HEMA, suggesting that testing for methyl methacrylate and ethyl acrylate would be beneficial in routine screening (39).

Metals

Nickel, chromium and cobalt, consistently identified as the most clinically relevant metal allergens, have been identified in products used to add colour to the skin, face and body care products, hair cosmetics and more. In some cases, the metal(s) are added deliberately to enhance cosmetic effect, while in many other cases the metal is a contaminant in the manufacturing process (40). Though initial exposures to metals and subsequent sensitization primarily stem from sources such as jewellery, clothing or medical devices, cosmetic metal exposure, especially nickel, has been investigated as a driver of ACD (41). A cross-sectional study of 1,843 women found the prevalence of nickel allergy to be similar between those reporting cosmetic dermatitis due to eyeshadow and mascara and those not reporting such symptoms (42).

The eyelids are particularly susceptible to ACD due to a thinner stratum corneum as well as frequent exposure to sweat, which may facilitate leaching of metal ions from cosmetic pigments. Low ion concentrations (<1 μg/g) can elicit ACD (43). In a study of patch tested patients with eyelid dermatitis, metals allergens were cited as some of the most frequently positive allergens. However, they found that nickel, cobalt, and chromium sensitization rates were not significantly different when comparing eyelid dermatitis patients to controls. Subsequent analyses of commercially available eyeshadows found greater than 5 ppm of at least one of nickel, cobalt or chromium in every product, even when they were not among listed ingredients (44). Though a level of 5 ppm may fall in an ambiguous zone of clinical relevance, repeated and prolonged applications to the thin eyelid skin can potentially elicit ACD when a single application may not (45). Literature linking ACD specifically to cobalt and chromium containing cosmetics is less developed. Cobalt contact allergy poses a clinical challenge in that causative exposures remain largely unknown, with a study of over 13,000 patients finding that only 20.1% of positive cobalt reactions could be linked to a source (46). The

most exposures were attributed to leather products and jewellery, with no significant contribution from cosmetics. A 2025 study investigating chromium allergy found that leather shoes and gloves were the most frequently identified exposures, with no definitively identified cosmetic exposures (47). Furthermore, hand, leg and foot dermatitis and age greater than 40 were significantly associated with chromium CD, which contrasts with the typical population of cosmetic uses which tends to be younger females.

Other metals are present in cosmetic products and are lesser causes of ACD. Gold is a frequent positive patch test reaction, but relevant reactions are less common. The most likely site for gold ACD is on the eyelids, where gold is transferred by finger contact from gold jewellery (48). There is also a correlation with the use of titanium dioxide (TiO2) containing sunscreen and gold ACD on the eyelids. TiO2 is a harder metal compared to gold, which can abrade gold particles from jewellery. These particles are transferred to the face and especially eyelids, inducing ACD (49).

Darker or more vibrant colours (e.g. in eyeshadows and blushes) often correlate with higher concentrations of iron (Fe), chromium (Cr) and nickel (Ni) (50, 51). Other less common metals reported to cause cosmetic ACD include aluminium, palladium, bismuth, manganese and platinum (52–56).

Periocular skin

The periocular region is particularly sensitive due to the thin skin of the eyelids, often being less than 1 mm thick and lacking subcutaneous fat. This permits more significant penetration of irritants and allergens, leading to inflammatory reactions and sensitization (57). The frequent application of cosmetics, particularly leave-on products such as eyeliner, mascara and foundation to this area, further contributes to the observed adverse effect rates. Patients reporting periocular dermatitis were nearly 80% women (58) and this striking predilection was attributed to sex differences in frequency of cosmetic usage.

Bacterial contamination of cosmetics poses an infection risk, with *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Candida albicans* cited as the main potential pathogens. Microbes can be introduced during manufacturing or after opening through repeat use. Makeup applicators can collect skin cells, sebum and moisture over time, which further facilitates bacterial contamination (59).

ACD accounts for a significant portion of periocular dermatitis. In a large-scale study of patients receiving patch testing across 57 centres, allergic contact dermatitis was responsible for 32% of all periocular dermatitis cases. Of the allergens tested, fragrance allergens, preservatives and metals were among most frequent sensitizers (57). Metals, more specifically nickel and gold, are cited as the most relevant allergen in patients with periocular dermatitis. Direct contact with the skin occurs through nickel-containing cosmetics (eyeshadows, mascara) or via transfer to the eyelid after touching costume or gold jewellery or other metal products (57). The allergens fragrance mix and balsam of Peru have also been cited as especially relevant offenders, with both ingredients being found in products including face creams, shampoos, soaps and eyeshadows (60). Cosmetic preservatives, particularly benzalkonium chloride, formaldehyde releasers and MI/MCI have significant sensitization ability in patients with eyelid dermatitis, with some of these ingredients being found in up to 20% of cosmetic products (61).

Overall, caution with fragranced products should be encouraged and avoidance should be complete in those reporting ACD. Complete abstinence from preservatives would be inappropriate as their antimicrobial effects are required to prevent spoilage. Use of low sensitizing ingredients should be prioritized.

Respiratory issues and cosmetics

Cosmetics are well known to cause skin sensitization, for which there is a robust body of supporting evidence. They are also thought to contribute to respiratory sensitization, rhinitis and asthma though strong evidence and validated approaches to identify respiratory sensitizers is sparse. Spray products are most capable of entering the respiratory tract. Propellant-based sprays produce particles <10 μm particles, of which 15% are respirable. Pump-based sprays generate larger particles, of which only 0.5% are respirable (62). In the US, asthma affects more male children (7.0%) than female (5.4%). However, asthma is more prevalent among adult women than men, with 10.8% of women suffering from asthma compared to 6.5% of men (63). This difference can be partly attributed to differences in PCP use by each sex. Indeed, studies have demonstrated a dose-dependent relationship between PCPs such as hairsprays and deodorants and adult asthma (64). Exposure to hair spray has also been shown to cause significant decreases in forced vital capacity in subjects with hyperreactive airways, while no such effect was observed among subjects with normal airways (65).

Photosensitivity reactions

Photosensitivity broadly refers to a collection of symptoms and conditions that are caused or exacerbated by exposure to sunlight. In cosmetic-induced photosensitivity, exposure to an external agent then sunlight leads to cutaneous symptoms (66),

which can be further categorized into phototoxic and photoallergic reactions.

Phototoxic reactions are common and are non-immune mediated. The underlying mechanism involves exposure to a photosensitizing agent that absorbs UVA radiation, leading to free radical formation, oxidative stress, cellular damage and inflammation (67).

In contrast, photoallergic reactions are delayed hypersensitivity reactions mediated by exposure to a photoallergen and UVA radiation. Upon absorption of radiation, the photoallergen joins with a carrier protein to form a complete antigen capable of eliciting a T-lymphocyte-mediated immune response (67).

Certain sunscreens and fragrances are known photosensitizers. UV filters such as benzophenones have demonstrated phototoxic potential mediated by free radical generation (68). As phototoxicity presents with sunburn-like symptoms, users may attribute reactions to sunscreen ineffectiveness as opposed to an adverse effect, delaying diagnosis. With regard to photoallergy, various ingredients have been implicated, most notably octocrylene, benzophenone-3 and butyl methoxydibenzoylmethane (69). From a period of 2009–2020, sunscreen agents were found to be responsible for nearly 90% of positive photopatch tests in North America (70). These ingredients are not only in sunscreens but also lip balms, moisturizers and colour correcting creams. Though not a common diagnosis, evaluation of photoallergy to sunscreens remains important to ensure patient safety and to inform future regulatory initiatives.

Fragrance ingredients such as oakmoss, benzyl alcohol, lime oil, bergamot oil and cinnamic aldehyde have demonstrated phototoxic, particularly photohaemolytic, effects *in vitro* (71). Additionally, orange, lemon and *Litsea cubeba* essential oils, often found in fragrance formulations, showed *in vitro* and *in vivo* phototoxic potential, namely due to the presence of known photoactive furocoumarins (psoralens) (72). Fragrance components such as musk ambrette and 6-methylcoumarin were also found to account for 11.6% of positive photopatch tests over a period of 20 years (73).

The utility of retinoids in restoring photoaged skin has given them significant popularity. They exert their effects through promotion of collagen synthesis while simultaneously suppressing collagen degrading enzymes (74), promoting epithelial proliferation and loosening intercellular connections in the stratum corneum (75). While this may contribute to maintaining a youthful appearance, increased epithelial turnover caused by retinoids has been found to contribute to higher UV penetration of the skin (76). Reassuringly, in four separate clinical trials, tretinoin was found to be neither phototoxic nor photoallergenic (77). Despite their pharmacological benefit, caution must be exercised with retinoid use and patients using retinoids should be mindful of sun exposure and ideally apply sunscreen daily.

Though the true prevalence of photosensitivity reactions requires more population-level analysis, they remain clinically significant. Patients who experience them may not immediately attribute the reaction to product use, instead believing cutaneous insult results from UV exposure. Consumers need to be made aware that sunscreens and fragrance components carry the risk of phototoxic or photosensitive side-effects to improve prompt recognition of relevant symptoms. Patients should be counseled that use of retinoids requires caution when combined with UV exposure. As many of these products are available over the counter, they may be associated with being devoid of side-effects, which is a misconception.

Paediatric considerations

Children have unique physiology that makes them more susceptible to dermal absorption of harmful substances due to their high BSA-to-body weight ratio and thinner skin. Prior to the fifth year of life, children have a thinner stratum corneum and experience increased transepidermal water loss which is thought to contribute to their increased skin sensitivity (78). The augmented permeability of the skin barrier leads to amplified penetration and absorption of chemicals and allergens, raising concerns about development of systemic toxicity and ACD (79). Newborns have an especially increased body surface area-to-body weight ratio that leads to elevated absorption of topically applied substances.

ACD has been documented in up to 20% of the paediatric population. It is mainly driven by common allergens including nickel, fragrances, preservatives and topical antibiotics, many of which are found in cosmetic products (80). In a study examining products marketed specifically for babies, 88% were found to contain at least one documented contact allergen with a mean of 2.21 allergens per product (81). Rates of ACD only increase with age due to accumulation of opportunities for exposure and sensitization.

An emerging concern surrounds younger populations being exposed to persistent marketing and consumption of digital content that encourages usage of cosmetics. The moniker “Sephora Kids” has been coined to address large numbers of children and adolescents flocking to stores in search of cosmetics whose safety in the paediatric population has not been robustly evaluated (82). Furthermore, increasing use of active ingredients such as retinols, exfoliating acids and vitamins, can lead to skin irritation, redness and photosensitivity among other side-effects (82). The consequences of increased absorption of cosmetic ingredients in paediatric populations remain unknown and require more thorough investigation.

Workplace exposures

Exposure to cosmetics in the workplace is particularly significant for beauticians and salon workers. They constantly handle products known to drive ACD, cause systemic side-effects and potentially lead to cancer. Workers should be counseled to exercise caution when handling products, particularly hair dyes and acrylates as there is credible evidence to support their allergenicity. Studies found that at times, workers" indoor exposure levels to volatile organic compounds exceed safe limits which is associated with pulmonary and carcinogenic effects, including asthma and leukaemia (83). In salon employees, many of these effects have been documented. Among a cohort of Iranian hairdressers, the incidence of cough, wheezing, shortness of breath and chest tightness was significantly higher when compared to a cohort of office workers (84). Another study in India measuring peak expiratory flow rate in salon workers found that their peak flow was significantly lower than predicted; proper training on using personal protective equipment was a significant protective factor (85). As a result, initiatives for proper ventilation need to be pursued to ensure employee health and workers should receive comprehensive training regarding proper PPE use to further reduce exposure levels.

Development of ACD is also more common among beauty workers, particularly hairdressers. Of 290 cases of occupational skin disease in hairdressers, 54% was ACD, ICD 44% and contact urticaria 5%. The leading allergens were hair dye ingredients, preservatives and persulfates (86). Para-phenylenediamine (PPD), used in hair dyes as a colourant, often leads to sensitization; hairdressers have been found to have a 5.4-fold increased risk of PPD sensitization compared to non-hairdressers (87). Preservatives, mainly MI/MCI, demonstrate elevated rates of sensitization among hairdressers compared to cosmetic consumers (10.5% vs. 3.1%) (88).

Pregnancy and lactation

Pregnant and lactating individuals face adverse effects that impact both themselves and their children. Pregnant individuals are advised to avoid numerous foods, drinks and activities to minimize exposure to infections, toxins and injury. They should be similarly counseled on the use of cosmetics and their prospective impacts on the child. Especially during the first trimester, when crucial formative processes are occurring, the use of cosmetics should be limited or eliminated completely. Of most concern and most well studied are the effects of endocrine disrupting chemicals on fetal and newborn development.

Chemicals such as parabens, phthalates and UV filters can cross the placenta and be contained in breast milk (89). Fetal or early life exposure to these chemicals can lead to numerous adverse effects including low birth weight, hormonal dysfunction, hepatotoxicity, kidney, thyroid and testis, neurotoxicity and neurodevelopmental disorders (90). The proposed mechanism by which these chemicals exert their effects is hypothesized to be multifactorial and mainly driven by oxidative stress, decreased levels of sex-hormone binding globulin, progesterone and testosterone, DNA methylation and intrauterine inflammation (90, 91).

Many studies have linked cosmetic use during pregnancy to low birth weight (LBW) and newborns that are small for gestational age (SGA) (92). Benzophenone-3 and methylparaben were linked to both LBW and SGA, prompting questions about intrauterine growth restriction and its associated consequences later in life (93). Furthermore, combined exposure, particularly during the crucial first and second trimesters, to bisphenols, triclosan and parabens was significantly and negatively associated with birth weight (94).

Certain ingredients contained in cosmetics have neurotoxic potential, which could lead to permanent disability and developmental delay. Prenatal exposure to dibutyl phthalate has even been suggested to be associated with neural tube defects through generation of oxidative stress and cell apoptosis (95). Dibutyl phthalate and butyl benzyl phthalate exposure during pregnancy was significantly linked to language delay in preschool aged children, possibly indicating an association with wider neurodevelopmental delay (96).

CONCLUSIONS

Global regulatory disparities lead to different formulations for different markets, leading to consumer confusion regarding safety standards. Existing regulations are not always followed. There exists a need for a central regulatory body that is able to establish widespread safety guidelines, maintain a cosmetovigilance system and conduct proper safety assessments. Harmonizing the discourse surrounding cosmetic safety has the potential to increase consumer safety, decrease adverse events and reduce healthcare and quality of life burdens globally.

Cosmetic usage can result in a spectrum of adverse effects that represent a significant clinical and public health concern. The most common reactions are dermatologic in nature, with contact dermatitis being the most frequently observed. While some reactions are temporary and reversible, others can lead to long-term systemic complications that could lead to serious consequences in vulnerable populations.

Healthcare providers can increase patient awareness about common ingredients and their associated side-effects and have a low threshold for diagnosing and testing for contact dermatitis. Patient education is of paramount importance.

The rapid growth of the cosmetic industry warrants robust research and clinical acumen to match. Research

focusing on larger-scale clinical studies to establish real-world correlation of mechanistic study findings, long-term health effects due to cumulative exposure, and determining levels of safe exposure for various ingredients are needed. Cosmetic products should contribute to quality of life and self-expression while presenting a minimal risk to health.

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