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A COMPREHENSIVE REVIEW OF HEALTH HAZARDS, TOXICOLOGICAL RISKS, AND REGULATORY GAPS IN COSMETIC AND PERSONAL CARE PRODUCTS

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კოსმეტიკური და პირადი მოვლის საშუალებების ჯანმრთელობაზე ზემოქმედების, ტოქსიკოლოგიური რისკებისა და რეგულაციის ასპექტების კომპლექსური მიმოხილვა

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რეზიუმე

კოსმეტიკური და პირადი მოვლის საშუალებების ფართოდ გავრცელებულმა გამოყენებამ ადამიანის ჯანმრთელობაზე ზემოქმედების დამალული საფრთხეები წამოწია წინა პლანზე. განსაკუთრებით პრობლემატურია სინთეზური ინგრედიენტები, რომლებიც შეიძლება ტოქსიკური, გენოტოქსიკური ან კარცინოგენული იყოს. სტატია აერთიანებს უახლეს მეცნიერულ მიგნებებს ისეთ ქიმიურ ნივთიერებებზე, როგორებიცაა ფთალატები, პარაბენები, მძიმე მეტალები და ნანომასალები. განხილულია ასაკობრივი და გენდერული გამოყენების ტენდენციები, ინგრედიენტების ნაზავების ეფექტები და ბუნებრივ ალტერნატივებთან დაკავშირებული დადებითი და უარყოფითი მხარეები. ნაშრომი ასევე ეხება რეგულაციების ხარვეზებს, რაც ხელს უშლის მომხმარებელთა დაცვას. სტატიაში გამოყოფილია უსაფრთხოებისა და მდგრადობის თანამედროვე შეფასების მიდგომები და რეკომენდაციები კოსმეტიკური ინდუსტრიის გაუმჯობესებისათვის. თეზისი მიზნად ისახავს შექმნას საფუძველი ისეთი რეგულაციებისათვის, რომელიც ადამიანისა და გარემოს ჯანმრთელობას პირველ ადგილზე დააყენებს.

Introduction: In modern societies, beauty and personal care routines are deeply embedded in daily life, propelled by cultural expectations, social media, and industry marketing. However, behind the allure of flawless skin and self-enhancement lies a complex matrix of synthetic chemical exposures. While offering aesthetic benefits, many cosmetic products contain substances with toxic, genotoxic, or carcinogenic potential. This paper explores the evolving understanding of such ingredients, regulatory responses, and consumer health implications.

Goal: Aim of the research was to study and analyzed aspects of health hazards, toxicological risks, and regulatory gaps in cosmetic and personal care products.

Methodology: The material of the article was the data from scientific publications, which were processed, analyzed, overviewed and reviewed by generalization and systematization. Research studies are based on a review/overview assessment of the development of critical visibility and overlook of the modern scientific literature. Use the following databases: (for extensive literature searches to identify aspects health hazards, toxicological risks, and regulatory gaps in cosmetic and personal care products). PubMed, Medline, Web of Science, Scopus, Web of Knowledge, Clinical Key, Tomson Reuters, Google Scholar, Cochrane library, and Elsevier foundations, national and international policies and guidelines.

Results and Discussion. One of the most prominent observations is the widespread use of harmful chemical ingredients such as parabens, phthalates, formaldehyde-releasing preservatives, and heavy metals. These compounds have been consistently linked with endocrine disruption, genotoxicity, reproductive toxicity, neurotoxicity, and various forms of cancer. Parabens, commonly used as preservatives, mimic estrogenic activity and interfere with hormonal regulation, posing risks to breast tissue development and reproductive health. Similarly, phthalates, especially diethyl phthalate (DEP) and di-n-butyl phthalate (DBP), are frequently found in fragrances and have been associated with reduced sperm count, altered fetal development, and thyroid dysfunction. Their detection in human urine and breast milk across diverse populations underscores the pervasive exposure through dermal absorption, inhalation, and incidental ingestion.

Among the most critical findings is the detection of heavy metals such as lead, mercury, cadmium, and arsenic in common cosmetic products including lipsticks, eye shadows, and skin-lightening creams. Even at trace levels, these metals are bioaccumulative, and their presence in products applied near mucous membranes or broken skin elevates systemic absorption risks. Lead exposure, for instance, has been strongly correlated with neurobehavioral deficits in children, infertility in adults, and hypertensive disorders. Regulatory action in Europe has attempted to minimize such risks, yet imported and counterfeit products continue to circumvent these safeguards in many low- and middle-income countries.

Overall, the evidence underscores an urgent need for a more integrated, precautionary approach to cosmetic product development and regulation. It is no longer sufficient to evaluate ingredient safety in isolation. A systems-based assessment that includes mixture toxicity, cumulative exposure, environmental impact, and vulnerable population risk is necessary to ensure true product safety. This approach, coupled with advanced analytical methods, consumer education, and international cooperation, could reshape the cosmetic industry toward greater responsibility and transparency.

Toxic Ingredients and Their Mechanisms of Action, Synthetic Chemicals of Concern: Phthalates and parabens disrupt hormone regulation; Formaldehyde, hydroquinone, and coal tar dyes exhibit carcinogenic properties; Acrylates, common in nail care, are linked to skin disorders and systemic toxicity.

Heavy Metals: Widespread in makeup and hair products, metals like lead, arsenic, and mercury penetrate skin barriers, accumulate in tissues, and pose mutagenic and neurotoxic risks.

Nanomaterials: Titanium dioxide and zinc oxide nanoparticles, used for their UV-blocking capabilities, may induce oxidative stress, DNA damage, and cellular toxicity upon dermal absorption or UV exposure.

Natural-Based Ingredients: Promise and Precautions: Natural cosmetics have surged in popularity, perceived as safer alternatives. Common components such as aloe vera, lavender oil, and argan oil offer antimicrobial and anti-inflammatory properties. However, essential oils and plant extracts may still cause skin irritation, allergic reactions, or endocrine effects, especially with improper formulation. Not all natural means non-toxic.

Cumulative and Mixture Toxicity: Cosmetics often contain complex chemical mixtures. These combinations can produce additive, synergistic, or potentiation effects, increasing toxicity unpredictably. Mixtures may influence each other's metabolism, exacerbate genotoxicity, or interfere with hormone signaling in ways not evident when ingredients are assessed individually.

Cosmetics and personal care products reveal a troubling paradox: while these products are marketed as tools for self-care, confidence, and beauty enhancement, their composition often includes substances that threaten human health and well-being. From endocrine-disrupting chemicals like parabens and phthalates to carcinogenic compounds such as formaldehyde and coal tar derivatives, a wide

array of ingredients used in everyday cosmetics pose significant toxicological and genotoxic risks. These findings are not merely theoretical but are supported by human biomonitoring studies, occupational health reports, and growing epidemiological evidence. What makes these risks particularly insidious is the combination of chronic exposure, product layering, and chemical mixtures that act synergistically to exacerbate toxicity. Additionally, vulnerable populations—including children, pregnant women, and beauty industry workers—are disproportionately affected. Despite the scale of exposure, regulatory frameworks in many countries remain outdated, fragmented, or insufficient. The lack of mandatory pre-market safety evaluations in jurisdictions like the United States permits a high degree of corporate discretion in ingredient use, while even more progressive systems such as those in the European Union fall short in evaluating final product formulations and cumulative exposure effects. While natural ingredients are often presented as safer alternatives, their misuse, improper formulation, and lack of robust toxicological evaluation present risks of their own. Moreover, the growing use of nanotechnology in cosmetic applications opens up new frontiers of risk and uncertainty, particularly regarding dermal penetration and systemic bioaccumulation.

Conclusions. While cosmetics enrich aesthetic appeal, their chemical complexity introduces substantial human health risks, particularly under current regulatory gaps. A multidisciplinary, collaborative effort—combining scientific rigor, policy innovation, ethical manufacturing, and informed consumer choice—is essential for building a safer and more sustainable beauty industry. A combination of stronger regulatory oversight, mandatory mixture toxicity testing, transparent labeling, and investment in alternative, non-toxic ingredients is essential. Just as importantly, empowering consumers through education and transparent access to product safety data will help shift market dynamics toward safety and sustainability. Bridging the gap between cosmetic innovation and consumer safety is not just a scientific challenge—it is a moral and regulatory imperative.

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SUMMARY

The widespread use of cosmetic and personal care products has introduced a hidden dimension of health risks due to the presence of synthetic and potentially hazardous ingredients. This review synthesizes current scientific evidence on the toxicological and genotoxic effects of chemical constituents commonly found in these products, such as phthalates, parabens, heavy metals, and emerging nanomaterials. The paper also examines age and gender-based usage patterns, the role of chemical mixtures, and recent findings on naturally derived alternatives. Moreover, it highlights the limitations of current regulatory frameworks across global jurisdictions and emphasizes the need for advanced safety assessments, green chemistry principles, and empowered consumer engagement. In doing so, this review outlines a path forward for a safer, more transparent cosmetic industry that prioritizes human and environmental health.

Keywords: cosmetics, toxicology, endocrine disruptors, carcinogens, nanotechnology, regulation