Review

Impact of Synthetic Cosmetic Ingredients on the Human Respiratory System: A Mechanistic Insight

Yohannes Desalegn Wirtu *, Umer Abdela Godana , Gudina Terefe Tucho

Posted Date: 11 March 2025

doi: 10.20944/preprints202503.0756.v1

Keywords: synthetic cosmetic ingredients; respiratory health; phthalates; inhalation exposure; regulatory guidelines for cosmetics; parabens; formaldehyde; natural alternatives in cosmetics

 doi:10.20944/preprints202503.0756.v1

Review

Impact of Synthetic Cosmetic Ingredients on the Human Respiratory System: A Mechanistic Insight

Yohannes Desalegn Wirtu [1], Umer Abdela Godana [1] and Gudina Terefe Tucho [2]

[1] Department of Environmental Science, Madda Walabu University, Bale-Robe, Ethiopia

[2] Department of Environmental Health Science and Technology, Institute of Health, Jimma University, Jimma, Ethiopia

* Correspondence: author: Yohannes Desalegn (yohannisdesalegn@gmail.com)

Abstract: Synthetic cosmetic constituents have also been a concern in recent decades due to their potentially adverse effects on human respiratory health. This review describes the occurrence of some harmful synthetic ingredients in cosmetics, including phthalates, parabens, VOCs, and microplastics, and discusses their pathways of inhalation and mechanisms of action. Both short- and long-term respiratory effects, especially in sensitive populations, are discussed together with the regulatory framework governing cosmetic safety. The review also points out that the demand for safer alternatives is growing, and natural and organic ingredients and the principles of green chemistry play a key role in reducing harmful inhalation risks. It further identifies gaps in current research, such as the need for longitudinal studies and the need to understand the interplay between synthetic ingredients and environmental factors. By dealing with these challenges, the cosmetic industry will move closer to a more consumer health-and safety-friendly product development.

Keywords: synthetic cosmetic ingredients; respiratory health; phthalates; inhalation exposure; regulatory guidelines for cosmetics; parabens; formaldehyde; natural alternatives in cosmetics

1. Introduction

The worldwide cosmetics market is worth billions, and synthetic materials are important for making many goods like perfumes, hair sprays, powders, and personal care products. Ingredients like phthalates, parabens, VOCs, and artificial scents are commonly used because they help products work well, last longer, and smell nice. Still, there is increasing worry about the possible health dangers these substances pose, especially how they might affect human lung health when inhaled (Hoppin, Ulmer and London, 2004; Bornehag and Nanberg, 2010).

Many cosmetic ingredients made synthetically come in forms that can be breathed in, like sprays and powders, which raises the chance of affecting the lungs(J. H. Kim et al., 2018). This exposure can cause both short-term and long-term lung problems, such as irritation, worsened asthma, bronchitis, and chronic obstructive pulmonary disease (COPD)(D. Kim et al., 2018). Breathing in tiny particles and chemicals from these products has been associated with lung inflammation and stress, which can make already existing lung issues worse or lead to new ones (Leikauf and Kim, 2020).

Many cosmetics use synthetic ingredients, but not much research looks at their long-term health effects, especially regarding respiratory issues. Most studies so far have concentrated on skin reactions or overall toxicity, creating a big gap in knowledge about how these substances impact the lungs. Also, current research often ignores the combined effects of ongoing, low-level exposure that many users face every day (Nurmatov et al., 2015). Additionally, vulnerable populations, such as children, the elderly, and individuals with pre-existing respiratory conditions, may be disproportionately affected, but research targeting these groups is sparse (Pneumologia et al., 1996).

For example, there are significant knowledge gaps about the actual effects of synthetic cosmetic ingredients on respiratory health. First, relatively few long-term studies have investigated the

 doi:10.20944/preprints202503.0756.v1

cumulative effects of chronic inhalation of these ingredients, which leaves the long-term respiratory consequences uncertain (Mpayipheli et al., 2024). However, there is little information about the effects of these ingredients on sensitive groups (that is, children, old people, and people with pre-existing respiratory disease) (Dondi et al., 2023).

The biological mechanisms by which synthetic cosmetic ingredients can damage the respiratory system by causing irritation, inflammation, and oxidative stress are also poorly understood (Mujtaba et al., 2021). In addition, further research is needed to examine the inhalation risks of different pharmaceutical delivery forms of cosmetics including aerosols and powders, and how these influence the total risk of respiratory conditions (Oh and Kim, 2020).

t is important to know the respiratory health risks of synthetic cosmetic ingredients for many reasons. First, millions of consumers use cosmetic products every day, sometimes in forms that can be inhaled, such as sprays, powders, and aerosols. As you can see, the risk of widespread exposure to harmful chemicals is high. Evaluating these risks is critical in alerting consumers to possible health risks and enabling them to make better decisions.

Second, this research could inform the cosmetic industry about the application of precautions during product formulation, preventing, and potentially leading to the formulation of safer alternatives to automobiles in an occupational manner. For instance, through adopting green chemistry practices, harmful synthetic ingredients could be replaced by natural or bio-based alternatives (Warner, Cannon and Dye, 2004). In particular, these findings from this study can guide the regulatory agencies to establish stricter guidelines and labeling requirements for mandibular jaw exercisers and keep consumers more well protected from such harmful exposures (Health Canada, 2021).

Finally, This research has public health implications, specifically for vulnerable populations. By determining who has the greatest chance of being affected by this, and figuring out what processes damage the organs of the human body, it becomes possible to create targets to prevent damage in these individuals. The main goal of this study is to evaluate the respiratory health risks of synthetic cosmetic ingredients.

2. Approach

This review included 120 relevant materials and followed a systematic review process aimed at achieving a comprehensive and impartial assessment of the extant literature. This is the base of the selection criteria for this review, which aims to include articles, clinical studies, meta-analyses, and systematic reviews that analyze the effects of synthetic cosmetic composition on the respiratory system. It should include diverse populations, including children, the elderly, people with pre-existing respiratory conditions, and the general consumer. Research needs to be done on key synthetic ingredients such as phthalates, parabens, formaldehyde, VOCs, microplastics, and fragrances. We also prioritize studies reporting both short- and long-term respiratory health outcomes (eg, irritation, asthma, bronchitis, and COPD). All studies from developed and developing countries worldwide will be included and prioritized if published in the last 10 years to capture a global perspective.

Non-peer-reviewed sources, such as blog posts or promotional materials from cosmetic companies, and studies not focused on the respiratory health impacts of synthetic cosmetic ingredients, instead emphasizing skin or other unrelated health effects, were excluded. Research with insufficient data or methodological clarity, duplicates, and those older than 10 years were excluded—unless they were seminal works essential to the field. Case reports or anecdotal studies that do not offer broad or generalizable insights into respiratory health trends related to cosmetic ingredients are also excluded from consideration.

A systematic literature review to evaluate the health effects of synthetic ingredients employed in cosmetics on the respiratory system is achieved using various search strategies. A general search might start with keywords that include “synthetic cosmetic ingredients” or “chemical ingredients in cosmetics” combining with “respiratory health” or “lung health” or “respiratory effects” to retrieve

 doi:10.20944/preprints202503.0756.v1

general studies related to respiratory concerns from exposure to cosmetic chemicals. To focus on specific harmful ingredients, another search can include terms like **"phthalates" or "parabens" or "formaldehyde" or "VOCs" or "microplastics"**, paired with **"inhalation" or "exposure" or "respiratory effects"** to capture research discussing the inhalation risks of these substances.

To explore particular respiratory endpoints, for example, search strings like "acute respiratory effects" or "chronic respiratory conditions" or "asthma" or "COPD" with "cosmetic ingredients" or "synthetic chemicals" will zero in on publications that examine both an acute and chronic impact on health from synthetic ingredient exposure. So for searching for purchasers of safer alternatives to synthetic cosmetic ingredients, a search strategy combining the terms "natural" or "organic cosmetics" or "safer alternatives" with "synthetic ingredients" or "cosmetic safety" will show useful papers about less harmful ingredients. Finally, regulatory aspects can be explored by using terms such as **"regulations" or "guidelines" or "safety standards"** alongside **"cosmetics" or "cosmetic ingredients"** to capture literature on existing safety measures and industry guidelines.

This review will bring several perspectives of data on the health effects of synthetic cosmetic ingredients concerning the respiratory system. The peer-reviewed literature on health, toxicology, environmental sciences, and cosmetic safety will be searched extensively from databases such as PubMed, Scopus, Google Scholar, Web of Science, and ScienceDirect. These databases cover a wide variety of studies, from experimental research, and review articles, to case studies that are essential to the respiratory risks associated with synthetic chemicals.

Furthermore, regulatory and health organizations such as the World Health Organization (WHO), the U.S. Environmental Protection Agency (EPA), Health Canada, and the Food and Drug Administration (FDA) will be referenced for their guidelines, reports, and data related to chemical safety and regulations. These organizations commonly release significant reports regarding public health risks, exposure limits, and the safety of cosmetic ingredients.

In addition, niche academic journals focusing on dermatology, toxicology, environmental health, and cosmetic science will be searched for relevant articles. These journals are often where the most recent research on the respiratory and overall health effects of cosmetic chemicals will be found. Another source would be systematic reviews and meta-analyses, as these collate existing research findings on the topic and provide a broad overview of known risks and gaps in research.

And, last but not least, government documents issued by health departments and laboratories, providing official data and information on cosmetics standards and laws. These reports are essential to getting a handle on wider health effects and regulatory policies involving synthetics in cosmetics. All these sources will be balanced to give a balanced review.

3. Results and Discussions

3.1. Common Synthetic Ingredients Harmful to Respiratory Health

Many synthetic ingredients used in cosmetics can have harmful effects on respiratory health. The substances, for example, Talc, are well-documented in the scientific literature for their potential to cause irritation or longer-term respiratory problems. Although it is used in many cosmetic products like powders, there is evidence linking inhaled talc to respiratory conditions such as chronic lung inflammation, particularly in occupational settings where dust exposure is more significant(Fiume et al., 2015).

Formaldehyde-releasing agents, such as quaternion-15 and Dimethylol Dimethyl,(DMDM) hydantoin, are common in hair straightening and preservation formulations. These agents slowly release formaldehyde, which is a known irritant and carcinogen. Studies show a clear link between formaldehyde exposure and asthma symptoms, as well as other respiratory issues (Dahlgren and Talbott, 2018).

Fragrances and volatile organic compounds (VOCs) can also trigger asthma attacks and cause discomfort in sensitive individuals. Many fragrances contain a variety of chemicals that, when inhaled, can irritate the respiratory system and exacerbate conditions like asthma or allergic rhinitis.

 doi:10.20944/preprints202503.0756.v1

VOCs, found in air fresheners, sprays, and some cosmetics, are also associated with a variety of health issues, ranging from short-term irritation to longer-term chronic respiratory conditions (Steinemann, 2016; McDonald et al., 2018; Khalid and Abdollahi, 2021).

As awareness of these risks grows, many people are opting for products that are free from these harmful chemicals, particularly those with sensitivities or pre-existing respiratory conditions.

3.1.1. Common Synthetic Cosmetic Ingredients and Their Respiratory Impact

Cosmetic products often contain various synthetic ingredients that, while serving specific functions (such as preservatives, fragrances, and stabilizers), can pose significant risks to respiratory health.

Phthalates

The most common form of phthalates associated with plasticizers in consumer products has brought some important respiratory health effects such as asthma and reduced lung function (Haccuria et al., 2014). Evidence shows that phthalate exposure is likely to adversely affect lung development and immune functions, leading to higher risks of respiratory diseases (Yu and Wang, 2024). Epidemiological evidence underlines strong entanglements established between exposure to phthalates and airway inflammation (Yu and Wang, 2024). Biomarkers such as fractional exhaled nitric oxide seem to be indicative of explicit responses (Haccuria et al., 2014). In one study that evaluated the relationship between urinary phthalate metabolites and airway inflammation in children, the authors found that children with the highest urinary concentrations of phthalate metabolites had elevated FeNO levels, suggestive of ongoing airway inflammation (Cao et al., 2024; El Refay et al., 2024). Additionally, prenatal exposure to some phthalates is associated with asthma-related outcomes, reiterating the concept that early-life exposures can have long-term implications for respiratory health (El Refay et al., 2024). Although the evidence linking phthalates to respiratory issues is compelling, it remains inconsistent across various studies, indicating the need for further research to establish clearer causal relationships and effective public health interventions aimed at reducing exposure to these harmful chemicals (Braun, Sathyanarayana and Hauser, 2013; Yu and Wang, 2024).

Parabens

Parabens are synthetic preservatives widely used in all types of personal care products, pharmaceuticals, and food. Some health concerns have been raised regarding their potential for inhalation exposure, especially concerning aerosol or spray formulations (Adrianne Alaba et al., 2022). Although the primary concern regarding parabens is their potential to act as endocrine disruptors, there is now emerging evidence that parabens may also function as respiratory irritants (Boberg et al., 2010). One study carried out to establish an association between urinary paraben levels and outcomes in asthma found a positive relationship between some specific parabens, namely methyl, and propylparaben, and the frequency of emergency department visits for asthma among boys (Lesliam Quirós-Alcalá, Nadia N. Hansel, Meredith C. McCormack, 2017). This points to a possible perversion of parabens in asthma aggravation and indicates that their presence in aerosol products could lead to respiratory issues upon inhalation. Although the evidence is still developing, the findings highlight the need for further investigation into how parabens may affect respiratory health and contribute to conditions like asthma and allergic diseases (Boberg et al., 2010; Lesliam Quirós-Alcalá, Nadia N. Hansel, Meredith C. McCormack, 2017; Adrianne Alaba et al., 2022; Yu and Wang, 2024).

Volatile Organic Compounds (VOCs)

Commonly used cosmetic products that emanate VOCs include nail polish, deodorants, and hairsprays; from such products, volatile organic compounds, such as formaldehyde and toluene, are

 doi:10.20944/preprints202503.0756.v1

released (Wirtu, 2024). Symptoms associated with respiratory effects that result from the inhalation of VOCs into the lungs can, therefore, generate an immediate reaction in terms of respiratory conditions whereby an individual may start coughing, wheezing, or feeling irritation in the throat. Short-term exposures can result in these general adverse health effects that include irritation of the eye, nose, and throat, besides some headaches and dizziness (Davi de Almeida Neto et al.,2007). Long-term health effects due to moderate or heavy exposure to levels of VOCs are much more severe and smay include chronic obstructive pulmonary disease (Alford and Kumar, 2021; Subin Paul, G Nancy Angeline, Sakthi Arasu, Don J Maliyakkal, 2023) and other respiratory ailments (Makuvara et al., 2024). It has been reported that people with a pre-existing respiratory condition are at a higher risk of developing adverse effects due to VOC exposure than healthy individuals. For example, a study conducted in beauty salons showed that the levels of indoor VOC concentrations were far above those recorded outdoors; this explains how it led to a series of complaints regarding health among workers and also customers. This highlights the need for improved ventilation and regulations regarding the use of VOC-containing products in enclosed spaces to mitigate health risks associated with these compounds (Hadei et al., 2018; Kwon et al., 2018; Oh and Kim, 2020; Choi et al., 2023).

Microplastics and Nanoparticles

Microplastics, spotted in scrubs and other cosmetic formulations, bear serious inhalation hazards since they can get aerosolized (Preda et al., 2024). Inhalation of these minuscule particles has resulted in penetrating deep within the lungs of many individuals and can result in serious consequences such as pulmonary inflammation of the lungs and oxidative stress. Evidence suggests that microplastic inhalation may result in various health risks such as irritable conditions in the respiratory system and chronic conditions such as chronic obstructive pulmonary disease (COPD) (Khanna et al., 2024). Since it has been established that microplastics are present in lung tissues, health experts have begun to worry about the effect such a compound will have on the lung health status of people (Khanna et al., 2024). On top of all that compounds like sunscreens and lotions which contain nanoparticles are known to be able to penetrate the skin breaks or wounds that you have further reinforcing the inflammatory condition and oxidation of lung cavities (Lamichhane, G. et al., 2023). Microplastics have a complex history of toxicity, so the role of chronic exposure to them in serious respiratory illness needs some serious research to be fully comprehended (Lee et al., 2023; Borgatta and Breider, 2024).

Artificial Fragrances

Perfumes are composed of a mix of synthetic substances including phthalates and volatile organic compounds (VOCs), all of which are known to cause respiratory problems. These chemicals may irritate the lining of the respiratory tract adding to asthma, bronchitis, and other symptoms. It has been observed that inhalation of such substances often provokes reactions including cough, wheezing, and sore throat(Cunniffe et al., 2024). Existing respiratory disorders such as asthma can be aggravated with even small amounts of fragrance exposure (Cunniffe et al., 2024). Additionally, the use of fragrances containing VOCs is also linked with other respiratory diseases, which puts one's health at risk, considering how widely they are used in personal products (Son, 2024). The presence of these harmful chemicals not only affects the respiratory health of an individual but even has the potential to have systemic effects and therefore requires a cautious approach and prevention of the use of fragranced products in regular use (De Groot, 2020; Cheng, Chen and Shih, 2023; Rádis-Baptista, 2023).

3.2. Microplastics and Nanoparticles

Nanoparticles and microplastics have become all the rage in cosmetic products because of how useful they are, but they have the potential to be harmful concerning one's respiratory health.

 doi:10.20944/preprints202503.0756.v1

Microplastics are typically contained in exfoliators and other product formulations, while being microscopic, they can become airborne, creating inhalation risks. Some studies show these small synthetic particles can infiltrate the lungs leading to painful inflammation as well as the creation of reactive oxygen species. On the other hand, nanoparticles which are used in lotions and sunscreens due to their usefulness in sunscreen protection can also be harmful due to their physical dimensions as they can pass through the human body's defense system. There is ample evidence that suggests exposure to these particles can result in various negative effects concerning one's health such as respiratory tract irritation, worsening of asthma, or even chronic obstructive pulmonary disease (COPD). The presence of microplastics and nanoparticles in cosmetic products makes it necessary to conduct more research into the implications of long-term use on respiratory health and overall health as the possibility of chronic exposure can cause detrimental health issues in the population.

3.2.1. Microplastics

Microplastics, which are less than 5 millimeters in size, are a common ingredient in personal care products including facial scrubs and cleansers. During the application process, these microplastics have a chance of entering the lungs through inhalation. Such inhalation poses serious health risks which include respiratory distress and inflammation. Reports show that these particles are so small that they can diffuse through the lung's tissues which may worsen chronic breathing diseases (Leslie, 2014; Sharma and Kaushik, 2021). The long-term impacts associated with microplastic inhalation are still the subject of current research, however, there are rising worries regarding their accumulation in the human body and what adverse effects they might have (Blackburn and Green, 2022; Li et al., 2023). A good example of products that inhalable microplastics come from are facial scrubs containing polyethylene or polypropylene microbeads (Fendall and Sewell, 2009).

3.2.2. Nanoparticles

Nanoparticles are widely utilized in cosmetics because they enhance the texture, stability, and UV shielding of the product, and they fall within the range of 1-100 nanometers. Yet, due to this small size, they possess the capability of being inhaled to the deepest parts of the lungs, which raises pneumonia and poisonous-related concerns. Experiments have demonstrated that some nanoparticles as titanium dioxide and zinc oxide, do trigger inflammatory responses in lung tissue (Crosera et al., 2009). A common example is the use of titanium dioxide nanoparticles in sunscreens for their UV-blocking properties. These particles can be inhaled if aerosolized, exposing the user to a possible respiratory problem (Hoet, Brüske-Hohlfeld and Salata, 2004).

3.3. Silicones and Artificial Fragrance

Silicones and synthetic fragrances are ubiquitous in cosmetic formulations and personal care products, offering desirable textures and aromas while simultaneously presenting potential hazards to respiratory health. Prolonged exposure to these substances may aggravate pre-existing respiratory ailments, resulting in manifestations such as coughing, wheezing, and throat discomfort. Moreover, the lack of transparency in ingredient labeling permits manufacturers to designate these chemicals merely as "fragrance," thereby obscuring the potential risks that accompany their usage. In a similar vein, silicones, although esteemed for their capacity to generate smooth textures and augment product efficacy, elicit apprehensions regarding their long-term implications for skin and respiratory health. Certain silicones have been demonstrated to accumulate within the organism over time and may interfere with hormonal regulation. The amalgamation of these substances within cosmetic products underscores the necessity for consumers to be cognizant of potential health risks and to explore alternatives that emphasize safety and transparency in ingredient composition (Rádis-Baptista, 2023).

3.3.1. Silicones

 doi:10.20944/preprints202503.0756.v1

Silicones, which are synthetic compounds extensively utilized in cosmetic formulations, are highly regarded for their capacity to facilitate smooth application, impart luster, and confer water resistance. These compounds are commonly incorporated into products designed for hair care, skin hydration, and cosmetic enhancement. Although silicones are generally deemed safe for external application, certain studies indicate that inhalation of aerosolized silicone-containing products might result in respiratory irritation or trigger allergic responses. Moreover, there is an escalating concern regarding the potential accumulation of silicones within the environment, which prompts inquiries into the implications of prolonged exposure and the associated risk of respiratory sensitization. Investigations reveal that while silicones can establish a barrier that retains moisture and augments skin texture, they may concurrently obstruct the skin's inherent functions, including moisture regulation and oxygen exchange. This occlusive characteristic could potentially give rise to complications such as pore blockage and acne, particularly among individuals with oily or sensitive dermis. In addition, the ecological ramifications of silicones are considerable; they are non-biodegradable and can exacerbate pollution and bioaccumulation within various ecosystems. As consumers increasingly recognize these hazards, there is a burgeoning demand for alternative ingredients that are both efficacious and environmentally sustainable (Kostic and Pharm, 2021; Bains and Kaur, 2023). Prominent silicones like dimethicone and cyclopentasiloxane are frequently present in hair sprays and body mists, where the propensity for inhalation during application is notably increased (Ivanova et al., 2023).

3.3.2. Artificial Fragrance

Artificial fragrances are complex mixtures of synthetic chemicals and are generally used in cosmetics to impart fragrance. Most of these are phthalate-based and other irritating ingredients that can cause respiratory problems, especially among sensitive individuals. Artificial fragrances are associated with the induction of symptoms like asthma, headaches, and irritation to the nose upon inhalation. Studies have shown that the inhalation of these chemical fragrances can irritate pre-existing respiratory conditions and increase discomfort and health hazards for vulnerable groups. Furthermore, certain fragrance components are known allergens that can also contribute to respiratory problems and allergic reactions. Given the prevalence of artificial fragrances in personal care products and their potential health impacts, there is a growing call for greater transparency in ingredient labeling and more stringent regulations regarding their use in consumer products (Steinemann, 2009; Rádis-Baptista, 2023). The inhalation of volatile fragrance compounds has also been associated with increased airway resistance and allergic reactions (De Groot, 2020). Products like perfumes, scented lotions, and aerosol deodorants frequently contain artificial fragrances that become airborne, potentially causing respiratory discomfort (Nurmatov et al., 2015).

3.4. Health Effects of Synthetic Cosmetic Ingredients on the Respiratory System

A literature review on the health effects of synthetic cosmetic ingredients, especially concerning the respiratory system, has raised major concerns regarding both short-term and long-term effects. Among common synthetic ingredients in cosmetics, phthalates , parabens, and artificial fragrances have been associated with different respiratory problems, including airway irritation and exacerbation of asthma and bronchitis (Magdalena Fandiño-Del-Rio, Elizabeth C. Matsui, Roger D. Peng,John D. Meeker, 2022). Studies have shown that such chemical exposure can cause immediate symptoms, including coughing and wheezing, particularly among sensitive individuals (Subin Paul, G Nancy Angeline, Sakthi Arasu, Don J Maliyakkal, 2023) . Long-term exposures to these synthetic chemicals are associated with chronic respiratory diseases and other serious health conditions. This chemical complexity creates an enhanced level of risk, whereby interactions among multiple ingredients in such formulations may increase the severity of adverse effects. Moreover, the lack of transparency in labeling makes it difficult for consumers to gain insight into the possible health risks of synthetic cosmetics. As more people become aware of these issues, there is a growing demand that safer, more natural alternatives should be used in cosmetic formulations to reduce these health risks

 doi:10.20944/preprints202503.0756.v1

and improve general well-being (Siti Zulaikha, Sharifah Norkhadijah and Praveena, 2015; Alnuqaydan, 2024).

3.4.1. Short-Term and Long-Term Health Effects

Short-Term Effects

Short-term exposure to chemical cosmetic ingredients has been responsible for irritation, cough, wheezing, and shortness of breath among many people. People with sensitive airways or pre-existing respiratory conditions often report increased bronchial irritation and asthma attacks following the use of certain cosmetic products. For example, the FDA reports that ingredients of fragrance can impact the respiratory system, especially among those people suffering from asthma or allergic rhinitis. These, in turn, result in symptoms such as cough, phlegm production, and chest tightness. Also, research shows that parabens and phthalates are chemicals used in most cosmetics, which may be a source of worsening respiratory problems and even allergic reactions (Alnuqaydan, 2024; Kohli, Mittal and Mittal, 2024).

The cumulative effects of such synthetic compounds draw attention to the need for awareness of potential health risks among consumers, especially those related to cosmetic products containing known irritants or allergens. Because the use of these products is increasing, further research and regulatory scrutiny are expected to continue to ensure consumer safety and minimize health risks associated with synthetic cosmetics (Soppa et al., 2014; Wirtu, 2024).

For long-term exposure, chronic respiratory effects might include exacerbation of asthma and even the development of COPD from long-term exposure to aerosolized synthetic cosmetic ingredients. The more alarming factor in long-term, low-level exposure to VOCs and microplastics is its potential to accumulate in respiratory systems and contribute to disease progression (Thá et al., 2021).

3.5. Modes of Exposure (Aerosols, Powders, Sprays) and Exposure Risks

Cosmetics are often applied in forms that may become airborne, risking inhalation of the synthetics. The major avenues of exposure through inhalation include aerosols, powders, and sprays. These products release particles into the air, which, when inhaled, cause both acute (Alnuqaydan, 2024) and chronic respiratory health problems (Oh, Han and Mainelis, 2021). Inhalation exposure is of specific importance for aerosolized products, such as sprays and loose powders, because such a form can produce very fine particles that may reach deep into the respiratory tract (Table 1). Studies have shown that inhalation of such particles can cause immediate respiratory effects, including irritation, coughing, and wheezing, particularly among those with sensitive airways or with pre-existing respiratory conditions(Table 1) (Oh and Kim, 2020). Besides, long-term exposure to airborne cosmetic particles is associated with more serious health effects, such as chronic respiratory diseases. It was estimated that a substantial amount of the particles of these products could be deposited in the different parts of the respiratory system after inhalation, possibly causing long-term health defects. This fact has led regulatory bodies to underline the need to assess the inhalation toxicity of cosmetic ingredients when testing their safety, which means that consumer awareness is needed about the risks related to airborne exposure to synthetic chemicals in cosmetics (Canada, 2020; Cosmetic Ingredient Review, 2021)

Table 1. Health risks associated with inhalation exposure to synthetic cosmetic ingredients.

Exposure Source	Common Products	Primary Ingredients	Health Risks	References
Fragranced Products	Perfumes, deodorants, air fresheners	Synthetic fragrances (e.g., terpenes, aldehydes)	Asthma attacks, mucosal irritation, headaches, and breathing difficulties.	(Rádis-Baptista, 2023; Wirtu, 2024)

 doi:10.20944/preprints202503.0756.v1

Aerosolized Cosmetics	Hair sprays, body sprays, dry shampoos	Aerosolized particles containing preservatives and surfactants	Pulmonary irritation, reduced lung function, and chronic respiratory inflammation.	(Thá et al., 2021; Wirtu, 2024)
UV Filters in Sunscreens	Sunscreens	Oxybenzone, octinoxate	Endocrine disruption leading to long-term respiratory effects and systemic toxicity.	(Alnuqaydan, 2024; Wirtu, 2024)
Powder-Based Products	Talcum powder, makeup powders	Talc particles mixed with other additives	Inhalation hazards causing chronic lung damage and fibrosis over prolonged exposure periods.	(Thá et al., 2021; Alnuqaydan, 2024)
Cleaning Agents with Fragrances	Surface cleaners, laundry detergents	VOCs and secondary pollutants (e.g., formaldehyde)	Respiratory hypersensitivity and chronic inflammation due to prolonged indoor exposure.	(Rádis-Baptista, 2023; Wirtu, 2024)

Aerosols are widely used in cosmetic products like hairsprays, deodorants, and perfumes. These products are designed to release fine mists that disperse tiny particles into the air. Upon spraying, aerosolized particles can be inhaled, depositing substances in the nasal passages, trachea, bronchi, and lungs. The findings by Rothe et al. (2011), indicated that the size of the aerosol particles below 10 microns diameter are capable of reaching down the lower respiratory tract and thereby could cause irritation of the respiratory path and chronic ailments such as respiratory diseases after a prolonged period (Rothe et al., 2011). Common aerosol cosmetics: hairsprays made from synthetic polymers, and propellants have also irritant effects on the respiratory tract (Basinas et al., 2017). Deodorants with aluminum compounds and synthetic fragrances that can cause respiratory problems when inhaled (Sainio & Kanerva, 1995), and perfumes with synthetic fragrances and volatile organic compounds (VOCs) which may give rise to headaches, allergic reactions, and asthma exacerbations (Steinemann, 2009).

Powders used in cosmetics can also become air-born during application: talcum powder, foundation, and blush. Many small particles are released with loose powders, and these remain in the air a long time, allowing for inhalation into the respiratory system, where they irritate the mucous membranes. As per Johnson et al., (2022), the inhalation of powders, especially those containing talc or silica, is known to cause irritation in the lungs and serious conditions such as talcosis. Examples of cosmetics that are in powder form include loose face powder and foundation, which usually contain talc or mica, both of which may be harmful upon inhalation over a long period (Johnson et al., 2022). Talcum powder, especially with contamination of asbestos, has been linked to respiratory diseases and even lung cancer (American Cancer Society, 2014).

Sprays, such as makeup setting sprays, body mists, and sunblock sprays, are all sprayed on in a fine mist that is easily inhaled into the respiratory tract. Like aerosols, sprays consist of tiny droplets that become suspended in the air, creating the opportunity for inhalation exposure. Many of these sprays contain complex combinations of solvents, polymers, and fragrances, many of which are VOCs capable of irritating the respiratory system or eliciting allergic responses (Nurmatov et al., 2015).

Some examples of spray-based cosmetics are setting sprays that often include alcohol, water, and polymers in their formulations, which are all irritants to the respiratory system (Loretz et al., 2008); sunblock sprays contain UV filters such as oxybenzone and octocrylene, which could also become aerosolized to result in inhalation exposure (Nurmatov et al., 2015).

Inhalation risks are of primary concern during the application of these products, especially in poorly ventilated, confined areas. The minute size of particles in aerosols, powders, and sprays allows them to reach deep into the respiratory system, raising concerns about possible accumulations of harmful substances. Chronic exposure to synthetic ingredients in aerosolized form has been linked to respiratory problems such as asthma, bronchitis, and chronic inflammation of the respiratory tract (Rothe et al., 2011).

 doi:10.20944/preprints202503.0756.v1

3.6. Inhalation Pathways and Exposure Risks

The mode of exposure greatly influences the degree of respiratory risk for cosmetic products. Aerosols, powders, and sprays have a higher chance of being inhaled and penetrate deeper into the respiratory system. It is suggested that the inhalation of fine particulate matter from these products may cause irritation and inflammation of the airways, worsening pre-existing respiratory diseases (Laycock et al., 2020). For example, studies from the Cosmetic Ingredient Review indicate that particles emitted from cosmetic aerosol products can deposit throughout the respiratory tract and a significant amount can be deposited in the tracheobronchial and alveolar regions of the respiratory tract, where adverse health effects may be caused (Vinnikov et al., 2023). Moreover, with inhalation exposure to the particles, subjects with hypersensitive airways or who suffer from asthma are considered to be at greater risk of increased irritation of bronchial airways following exposure, as their disease symptoms may become exacerbated by this. These results reflect the importance of considering inhalation risks when the use of cosmetic products gives rise to airborne particles and stress caution in formulation and application strategies to minimize possible respiratory health effects (Ezendam, Ter Burg and Wijnhoven, 2011; Rádis-Baptista, 2023).

3.6.1. Aerosols and Sprays

Aerosolized products, such as deodorants and hair sprays, release a fine particulate that may be inhaled deep into the lungs (Balasubramani and J, 2022). These frequently contain synthetic ingredients, such as VOCs and phthalates, linked to respiratory irritation and long-term lung damage. Evidence shows that the inhalation of such fine particulate matter is associated with immediate symptoms like coughing, wheezing, and irritation of the throat, particularly among people with pre-existing respiratory diseases (Sonwani et al., 2021). For instance, it has been proved that the size of particles formed from aerosolized cosmetics can be small enough to reach the deep parts of the lungs and may result in inflammation and oxidative stress. The Cosmetic Ingredient Review has pointed out that most of the particles generated through the use of aerosol products are respirable and can lead to chronic respiratory problems in the long run. Furthermore, exposure to these artificial chemicals can cause flare-ups of asthma or bronchitis, thereby necessitating awareness among consumers about the potential dangers arising from the application of aerosolized cosmetic products (Nurmatov et al., 2015).

3.6.2. Powdered Cosmetics

Powders are the easiest to become airborne in makeup and other beauty products, freely exposing them to inhalation. These usually contain talc, silica, or other synthetic substances that might be accumulated in the lungs and create chronic inflammation. The most common lung effects due to inhaling talc include cough, dyspnea, and diminished lung function. Health Canada has mentioned that inhaling loose talc powder can cause nontoxic lung effects like pulmonary fibrosis, a scarring of the lungs, which comes about because of chronic inflammation caused by talc accumulation in the lungs over many years (Mishra et al., 2019). Further, studies have demonstrated that fine particulate matter from loose powders acts to worsen respiratory conditions among those with predisposing factors like asthma or bronchitis. The health concerns following the inhalation of these particles are enormous, thus putting into light the precautionary measures in the handling of products producing these particles. With increased awareness of the possible risks of these cosmetic ingredients, consumers are advised to consider alternatives that minimize exposure through inhalation (Thá et al., 2021; Balwierz et al., 2023).

4. Mechanisms of Respiratory Damage from Cosmetics Ingredients

The major ways synthetic cosmetic ingredients act on the respiratory system are through irritation and inflammation. Fine particulate matter, VOCs, and nanoparticles may reach deep into the respiratory tract and induce oxidative stress and inflammation (Table 2). Long-term exposure to

 doi:10.20944/preprints202503.0756.v1

these processes may result in tissue damage and impairment of lung function (Portugal et al., 2024). Other components, such as VOCs, can induce systemic effects by exacerbating pre-existing conditions like asthma or causing new-onset respiratory diseases (Sonwani et al., 2021).

Table 2. Mechanisms of respiratory impact from synthetic cosmetic ingredients.

Category	Key Ingredients/Compounds	Mechanism of Impact	Respiratory Effects	References
Volatile Organic Compounds (VOCs)	Synthetic fragrances (e.g., linalool, limonene, benzene derivatives)	VOCs react with ozone and hydroxyl radicals to form secondary pollutants like formaldehyde and ultrafine particles.	Breathing difficulties, asthma exacerbation, mucosal irritation, and reduced exhalation volume.	(Rádis-Baptista, 2023)
Aerosolized Particles	Aerosols, powders, sprays containing preservatives or perfumes	Inhalation of fine particles leads to pulmonary irritation and deposition in the respiratory tract.	Pulmonary irritation, reduced airflow velocity, and potential long-term lung damage.	(Alnuqaydan, 2024)
Allergenic Fragrance Chemicals	Hydroxyisohexyl 3-cyclohexene carboxaldehyde, isoeugenol, cinnamal	Direct sensitization of the respiratory tract or allergic reactions upon inhalation.	Respiratory allergies, asthma attacks, and contact urticaria with respiratory symptoms.	(Rádis-Baptista, 2023)
Endocrine Disruptors	Parabens, phthalates	Hormonal imbalances affecting respiratory function through endocrine disruption mechanisms.	Chronic inflammation and altered respiratory health due to hormonal interference.	(Rádis-Baptista, 2023; Alnuqaydan, 2024)
Secondary Pollutants	Formaldehyde, ultrafine particles from VOC-ozone reactions	Persistent indoor air pollutants	Chronic inflammation of the	(Rádis-Baptista, 2023)

 doi:10.20944/preprints202503.0756.v1

		formed by chemical reactions of synthetic cosmetic ingredients.	respiratory tract and increased inflammatory biomarkers.	

4.1. Volatile Organic Compounds (VOCs)

Organic Volatile Compounds, most present in cosmetic products like perfumes and hair sprays, have a significant impact on respiratory health upon inhalation. Upon the inhalation of such compounds, these toxic entities make their way deep into the airways and thereby act to irritate the respiratory mucosa. The effects often result in inflammation and the activation of the mechanisms for oxidative stress in the respiratory system. Other research has indicated that VOCs react with other air pollutants to form secondary pollutants such as ozone, which worsens the condition of people with respiratory diseases like asthma. A study by Nurmatov et al. (2015) pointed out the role of VOCs in aggravating respiratory conditions through these chemical interactions (Nurmatov et al., 2015).

4.2. Interaction of Chemicals with Respiratory Tissue

The interaction between synthetic cosmetics and respiratory tissues is important in determining the mechanisms of respiratory damage. When inhaled, these chemicals may interact with respiratory epithelial cells, induce immune responses, and cause tissue injury. It has been established that the inhalation of some commonly used cosmetic chemicals, like phthalates and parabens, leads to reduced lung function and increased vulnerability to respiratory diseases. A longitudinal study published in The Lancet Planetary Health presented that in-utero exposure and in the early neonatal period to these chemicals was associated with reduced lung function at age six and twelve, suggesting long-lasting effects on respiratory health (EWG, 2019).

Also, products in aerosol form, such as deodorants and hair sprays, emit ultra-fine particles that can reach deep into the lungs and cause irritation and inflammation of the airways. These particles mostly contain VOCs and other synthetic ingredients known to aggravate respiratory problems. The inhalation of such substances may provoke immune responses that further contribute to tissue damage and chronic respiratory conditions (Alnuqaydan, 2024; Wirtu, 2024).

The importance of these interactions for the elaboration of effective regulatory measures and consumer information on the possible risks of the use of synthetic cosmetics becomes relevant. The need for safer alternatives is emphasized by the currently growing evidence linking these chemicals to adverse health outcomes.

4.3. Mucosal Barrier Disruption

4.3.1. Epithelial Cell Interaction

The respiratory epithelium is an important barrier against inhaled irritants. Synthetic chemicals like formaldehyde, phthalates, and VOCs can diffuse through this barrier, inducing cellular damage and disrupting the integrity of the mucosa. Upon inhalation, these substances interact with respiratory epithelial cells, triggering immune responses that can lead to tissue damage. It has been observed that, when the integrity of the epithelial barrier is disrupted, it is less effective in protecting against environmental pollutants and pathogens. The airway epithelium is a critical determinant of respiratory tract integrity. It is composed of tightly linked cells that form a physical barrier to prevent harmful substances from reaching the underlying tissues. Disruption of this barrier may lead to increased permeability, allowing allergens and pathogens to penetrate easier and potentially worsening conditions such as asthma and COPD (Hiemstra, 2013; Kauffman, 2015).

 doi:10.20944/preprints202503.0756.v1

It has been established in numerous studies that exposure to various synthetic chemicals results in the disintegration of intercellular junctions, which include tight junctions and adherens junctions and are very crucial in maintaining the integrity of epithelium. This breakdown in junctions is associated with enhanced inflammation and susceptibility to infections (Kim, 2022).

Furthermore, the denuded epithelium might overly produce mucus and mediators of inflammation leading to airway obstruction and symptoms that are chronic. In brief, interactions between the respiratory epithelium and synthetic cosmetic chemicals have important implications for understanding possible human health effects. The integrity of respiratory epithelium needs to be safeguarded in order to prevent any kind of respiratory disease (Gloria Kang GJ, Ewing-Nelson SR, Mackey L, Schlitt JT, Marathe A, Abbas KM, 2018).

4.3.2. Increased Permeability

Exposures to the irritant, such as cosmetics, increase airway epithelial permeability to facilitate further access of allergens and noxious particles into the respiratory tissues. Such heightened permeability thus initiates an inflammatory response and a hypersensitivity reaction, further worsening respiratory conditions like asthma and allergic rhinitis. Scientific studies show that some synthetic chemical exposures, especially those to formaldehyde, phthalates, and volatile organic compounds, break the integrity of the airway epithelium. This disruption promotes the easier penetration of allergens and irritants that may trigger immune responses and cause tissue injury. Indeed, one study identified that increased permeability in the barrier is associated with structural changes in the airway epithelium, such as detachment of ciliated cells and decreased expression of key adhesion molecules like E-cadherin. These changes may lower the threshold for epithelial damage and promote a cycle of inflammation characterized by heightened sensitivity to environmental insults (Calvén, Ax and Rådinger, 2020).

Furthermore, allergens like house dust mites can act directly on the disruption of tight junction proteins within the epithelial barrier, thus further compromising permeability. This disruption promotes not only the entry of allergens but also constitutes a positive feedback mechanism by which inflammation is followed by further barrier dysfunction (Calvén, Ax and Rådinger, 2020; Pat et al., 2024).

Consequently, individuals with asthma or allergic rhinitis may experience worsened symptoms due to this compromised epithelial barrier(Jindal, 2016; Hellings and Steelant, 2020).

4.4. Activation of Immune Responses

4.4.1. Immune Cell Recruitment

The inhalation of synthetic chemicals in cosmetics may activate the resident immune cells, including macrophages and dendritic cells, in the respiratory tract (Ahmad, Nasser and Ahmad, 2024). These cells will, in turn, release cytokines and chemokines to recruit more immune cells into the site, causing local inflammation. While this provides a defense against inhaled irritants and pathogens, this very immune response may promote adverse health effects when such responses are elicited by the synthetic ingredients of cosmetics. Research has shown that exposure to irritants in cosmetics, such as formaldehyde, phthalates, and VOCs, results in considerable activation of the immune system (Panico et al., 2019). For instance, one study showed that the inhalation of fragrance allergens may cause immune responses in the airways that are characterized by enhanced cytokine production and the recruitment of inflammatory cells. This may lead to symptoms such as coughing, wheezing, and exacerbation of conditions like asthma and allergic rhinitis (Naqvi et al., 2022). Furthermore, the interaction of these synthetic chemicals with the respiratory epithelium disrupts normal barrier functions, increasing permeability and allowing allergens and harmful particles to penetrate deeper into lung tissues. This disruption not only enhances inflammation but also contributes to a cycle of hypersensitivity reactions that can worsen respiratory conditions over time. In summary, understanding how synthetic chemicals activate immune responses in the respiratory

 doi:10.20944/preprints202503.0756.v1

tract is important for assessing their possible health impacts and developing strategies to mitigate these risks (Thiriou et al., 2017).

4.4.2. Oxidative Stress Induction

Most cosmetic ingredients, particularly those with nanoparticles, produce ROS. It is this oxidative stress that causes damage to respiratory tissues and may also activate the signaling pathways that facilitate inflammation and respiratory injury (Naqvi et al., 2022). In general, the generation of ROS in lung epithelial cells may subsequently lead to inflammatory responses associated with respiratory pathologies. Because of their unique physicochemical properties, nanoparticles tend to produce excessive amounts of ROS upon exposure. Such oxidative stress may lead to extensive cellular injury, including lipid peroxidation, DNA breakage, and protein oxidation, potentially causing lung epithelial cells to undergo necrosis or apoptosis. It has been shown that these nanoparticles, upon interacting with respiratory tissues, induce immune responses manifested by the release of pro-inflammatory cytokines and chemokines, further enhancing inflammation and contributing to respiratory diseases such as asthma and COPD. Studies by Liu et al. (2020) and Yu et al. (2020) have shown that. Besides, ROS accumulation in lung epithelium results in the loss of cellular function and induction of chronic inflammation (Liu et al., 2020; Yu et al., 2020). All these factors may lead to persistent respiratory complications and underscore the importance of a mechanistic understanding of the impact of cosmetic nanoparticles on respiratory health (Manke, Wang and Rojanasakul, 2013; Mittal et al., 2014).

4.5. Cellular Toxicity and Apoptosis

Cytotoxicity: Some cosmetic chemicals (like formaldehyde) provide cytotoxic effects to respiratory epithelial cells, leading either to apoptosis (programmed cell death) or necrosis (uncontrolled cell death). For example, formaldehyde exposure increases death rates in lung cells, debilitating the epithelial barrier and potentiating diseases such as chronic obstructive pulmonary disease or COPD (Kang et al., 2022).

Research has shown that formaldehyde can lead to severe damage to respiratory tissues. In one such study, it was shown that exposure to high levels of formaldehyde caused histological changes to lung tissues, including cellular infiltration, thickening of bronchiolar walls, and destruction of alveoli, which cumulatively destroyed the integrity of the epithelial barrier. Such changes may increase the risk of respiratory infections and other chronic pulmonary disorders due to the loss of the protective function of the epithelium (Robert, Waritimi and Dare, 2012). These alterations can result in increased susceptibility to respiratory infections and chronic lung conditions due to the loss of protective epithelial function.

Moreover, the exposure to formaldehyde has been attributed to inflammation and injury to the lungs. It provokes an immune response that mediates further tissue damage, worsening respiratory diseases. It has been revealed in some inhalation studies that formaldehyde can reduce the activity of alveolar macrophages, a very key player in the immunity of the lungs, thus easily making one prone to respiratory infections and related complications (Lim et al., 2010). The cytotoxic effect of formaldehyde on respiratory epithelium is a health concern arising from its presence in cosmetic products. Prolonged exposure may lead to severe respiratory pathologies, thus demanding stringent regulation and monitoring of cosmetic ingredients.

Chronic Inflammation: Repeated or chronic exposure to the injurious cosmetic chemicals elicits a persistent inflammation response that leads to long-term tissue remodeling. Such chronic inflammation constitutes a major factor in the development of respiratory diseases such as chronic bronchitis and asthma. Indeed, a number of studies have demonstrated the ability of certain chemicals found in cosmetics to induce inflammatory responses in the respiratory system after exposure, including parabens, phthalates, and formaldehyde. For example, formaldehyde has been associated with heightened airway inflammation and impairment of respiratory epithelium that may

 doi:10.20944/preprints202503.0756.v1

compromise the integrity of the epithelial barrier, leading to an enhanced susceptibility to respiratory infections and conditions such as asthma (Alnuqaydan, 2024).

Long-term inflammation due to chronic exposure could bring about changes in lung structure and contribute to the pathogenesis of diseases such as chronic obstructive pulmonary disease and chronic bronchitis (Liu et al., 2022)..

The mechanisms underlying these effects involve the activation of immune responses releasing pro-inflammatory cytokines. These cytokines, in turn, recruit other immune cells to the site of exposure, thus prolonging inflammation and leading to tissue remodeling over time (Anderson and Meade, 2014). The cumulative effects of these inflammatory processes highlight the importance of understanding the long-term health impacts of cosmetic chemicals on respiratory health (Hantrakool et al., 2022).

5. Regulatory Gaps and Safety Concerns

Despite these possible health effects, little regulation has been developed regarding synthetic ingredients in cosmetics in general, and more particularly regarding inhalation safety. While most of the regulatory bodies focus on dermal safety, very few address the respiratory hazard that is posed by cosmetic ingredients becoming airborne. There is an immediate need for more restrictive guidelines concerning labeling and consumer awareness, and levels of permissible harmful chemicals in cosmetic products (Health Canada, 2021).

6. Review of Existing Regulations on Synthetic Ingredients in Cosmetics

The regulation of synthetic ingredients in cosmetics varies by region, with different agencies overseeing safety and use. Here's an overview of key regulations and guidelines:

6.1. United States

FDA Regulations: In the U.S., cosmetics are regulated by the Food and Drug Administration under the Federal Food, Drug, and Cosmetic Act. Cosmetics do not need to be approved by the FDA prior to entering the market, but the FDA can take action against products that are determined unsafe or misbranded after being released (FDA, 2021).

Ingredient Safety: The FDA has a Voluntary Cosmetic Registration Program wherein manufacturers can voluntarily report product ingredients. The Cosmetic Ingredient Review is responsible for reviewing the safety of cosmetic ingredients, including synthetic substances; however, submission for review is also voluntary (CIR, 2020).

6.2. European Union

Cosmetic products are regulated by the Cosmetic Regulation (EC) No. 1223/2009 in the EU. Every cosmetic product has to go through a CPSR before being placed on the market. A responsible person should be named for each product, who will look after the safety assessment and labeling of the product. The regulation then names specific annexes for substances that are prohibited-Annex II, restricted-Annex III, permitted colorants-Annex IV, and preservatives-Annex V. Notably, substances classified as carcinogenic, mutagenic, or toxic for reproduction (CMR) are banned unless specifically approved under certain conditions (European Chemicals Agency, 2021; European Commission, 2021).

6.3. Canada

Cosmetic Regulations under the Food and Drugs Act: Health Canada regulates cosmetics, including synthetic ingredients, requiring that all products be safe for use and properly labeled. Manufacturers must notify Health Canada of their products and their ingredients (Health Canada, 2021).

 doi:10.20944/preprints202503.0756.v1

Prohibited and Restricted Ingredients: There is maintained the list of prohibited and restricted substances, which insures that harmful synthetic chemicals are not allowed to be used in cosmetics.

7. Labeling and Consumer Awareness

Labeling is crucial for consumer safety and awareness regarding the presence of synthetic ingredients in cosmetic products.

7.1. Ingredient Transparency

Full Ingredient Disclosure: Most countries implement regulations requiring cosmetic products to indicate all ingredients on packaging for consumer safety and informational purposes. This transparency makes it easier for consumers to assess the products they use based on their composition, such as synthetic chemicals (FDA, 2021; Health Canada, 2021). Following is some overview of key regulations or guidelines concerning ingredient labeling in some regions.

According to the Cosmetic Regulation (EC) No. 1223/2009, every cosmetic product placed on the EU market must bear a full list of ingredients. The list should appear in descending order by weight and should be headed by the term "ingredients". This regulation ensures that the consumer will be able to identify and avoid certain substances, in particular allergens, but also promotes consistency among the member states, as this is under INCI name, which refers to International Nomenclature of Cosmetic Ingredients (Cosmetics Europe Annual Report, 2011).

In the U.S., cosmetic labelling is controlled by the Food and Drug Administration (FDA) through the Federal Food, Drug, and Cosmetic Act. The FDA requires all ingredients to be listed on the product label in order of predominance. Ingredients present in less than 1% may be listed in any order following those above this threshold. Color additives may also appear separately regardless of their concentration (Administration, 2022).

Likewise, in Malaysia, it is required by the National Pharmaceutical Regulatory Agency that all cosmetic products bear the complete ingredient declaration on its label. Ingredients shall appear on the list in order of descending weight when added and special provision is given to fragrances and colorants(Of and Products, 2017).

Use of Common Names: The International Nomenclature of Cosmetic Ingredients (INCI) system standardizes ingredient names, helping consumers easily recognize substances, including synthetic ingredients (CIR, 2020).

7.2. Allergen and Hazard Warnings

Labeling Requirements: Some legislations in certain regions require putting on labels those allergens, irritants, or any other harmful ingredients. The practice can increase consumer awareness of the potential risks linked with synthetic ingredients (European Chemicals Agency, 2021). Here's an overview of key regulations regarding allergen labeling in cosmetics:

7.2.1. European Union (EU)

The recent regulations in the EU have extended the number of allergens that should be labeled on cosmetic products from 26 to 81 allergens. This is to enhance consumer safety and transparency by making the manufacturer indicate the presence of such allergens in their products. The new regulations make sure that consumers can identify, with ease, any possible allergens, such as certain fragrances, preservatives, and hair dyes, to make informed choices on the products they use (European Commission, 2023; Jiménez, 2024).

7.2.2. United States

Although the FDA does not require allergen labeling for cosmetics, it does require that all ingredients in cosmetics be identified on the product label. Consumers are advised to look for known allergens on ingredient lists, as general terms such as "fragrance" can include several unidentified

 doi:10.20944/preprints202503.0756.v1

ingredients that may cause allergic reactions (U.S.A. Food and Drug Administration, 2022). The lack of a standard definition for terms such as "hypoallergenic" further complicates decisions about allergenic potential.

7.2.3. Australia

In Australia, the Consumer Goods (Cosmetics) Information Standard 2020 specifies the mandatory requirements for labeling cosmetic ingredients. While it does not particularly require allergy information, it encourages suppliers to include such information to enable consumers to avoid products that may provoke allergic reactions (Anaphylaxis, 2024). This standard aims to reduce the risk of accidental exposure to allergens in cosmetic products.

7.2.4. Canada

Health Canada requires all cosmetics products to indicate their ingredients clearly on the packaging. While it is not specifically mandated, identifying allergens on cosmetic packages, it is an appeal that consumers with sensitivities and allergies take special consideration to read the ingredient label of the product carefull (ACCC product safety, 2024).

Allergens and irritants on cosmetic labels must be highlighted, an important step toward enhancing consumer safety and awareness. In giving clear information about potential risks associated with synthetic ingredients, these regulations allow consumers to make safer choices about personal care products.

Consumer Education: Manufacturers are encouraged to clearly communicate the effects and risks of the synthetic ingredients used in products, thus enhancing consumer knowledge about product safety. The transparency is important since more and more consumers seek to make informed choices regarding the kind of products they use amid concerns over the potential health risks some cosmetics may possess with synthetic chemicals.

7.2.5. Importance of Ingredient Transparency

With appropriate labeling of synthetics, this aids consumers in noting allergens and irritants that cause adverse health effects. Certain common synthetic ingredients include the likes of parabens and phthalates linked to endocrine disruption and other reproductive health effects. Being widely used preservatives, parabens are related to mimicking estrogen due to their chemical structure, thus disrupting the normal flow of hormones. Such materials are pointed to with questions of their overall long-term effects on human health, particularly concerning increased risk for cancer

7.2.6. Health Risks Associated with Synthetic Ingredients

The presence of harmful substances in cosmetic products can lead to a range of health issues. Chemicals like formaldehyde, which is often used as a preservative, are known carcinogens and have been associated with respiratory conditions and skin irritations. Prolonged exposure to such chemicals can exacerbate existing health problems and contribute to chronic diseases (Kohli, Mittal and Mittal, 2024).

The "cocktail effect" further involves adverse reactions from interactions that might ensue from exposure to numerous different chemicals from the application of several different products that contain various synthetic ingredients; this is very possible according to Alnuqaydan (2024). This addresses the importance of comprehensive labeling that informs the consumer on not just individual ingredients, but also their potential interaction (Alnuqaydan, 2024).

7.2.7. Regulatory Landscape

Regulatory bodies in various regions are starting to take cognizance of the need for increased transparency about cosmetic ingredients. In the European Union, for example, regulations require that certain allergens be indicated on product labels for consumer safety(Wirtu, 2024). On the other

 doi:10.20944/preprints202503.0756.v1

hand, the U.S. FDA, though mandating ingredient listing, does not go as far as to specifically require allergen highlighting that could help improve consumer awareness (Panico et al., 2019).

8. Marketing and Claims

Most of the countries have legislation to avoid misleading cosmetic claims with terms such as "natural" or "organic." Consumers should realize that such terms do not guarantee the absence of synthetic ingredients. Here's an overview of the regulatory landscape and implications for consumers regarding these claims:

8.1. Regulatory Framework

EU laws include Regulation 655/2013, which lays down the guidelines for cosmetic claims in general and specifically for the terms "natural" and "organic." These guidelines require cosmetic claims to be truthful, supported by evidence, and cannot be misleading. However, with no standard definition of what really comprises a "natural" cosmetic product, this may create confusion among consumers in how the term is used on the market (Shapypro, 2024). In the United States, the FDA does not define the term "organic" for cosmetics; however, products labeled as organic must follow USDA regulations. That means that even if a product contains organic ingredients, it is still subject to the FDA regulations concerning safety and labeling. Importantly, the FDA makes it very clear that the presence of organic ingredients does not make a product inherently safer than those with synthetic components (FDA, 2022).

8.2. Misleading Claims and Consumer Awareness

Lack of clear-cut definitions of these terms, on the other hand, creates room for misuse with respect to marketing. For example, a company can term its products "natural," even though it may contain synthetically made ingredients. These practices mislead consumers into thinking they are buying much safer or more environmentally benign products when that may actually not be so (Coslaw, 2022). Also, greenwashing is the over-inflation or the incorrect marketing of products as natural and environmentally friendly. All these call for calls for the institution of tighter regulations and increased transparency to shield consumers from scams (Prodigia Cosmetics, 2023).

Claims about "natural" and "organic" in cosmetics need to be carefully weighed by the consumer. Knowing the regulatory mechanism will help consumers understand that such terms do not assure that no synthetic ingredients are included in the product (Health Canada, 2021).

Consumer Advocacy: Consumer advocacy is very helpful in bringing awareness about artificial ingredients in cosmetics, since consumers would be more discerning of labels and look at the health and safety concerns more knowledgeably. There are many non-profit groups and advocacy groups, for example, the Environmental Working Group, that work consistently to raise awareness among people through their work on the potential risk factors behind synthetic chemicals frequently used in personal care items. These organizations stress transparency in labeling to help consumers identify harmful chemicals like parabens and phthalates, associated with a number of serious health problems including endocrine disruption and reproductive problems (Kohli, Mittal and Mittal, 2024).

8.3. Regulatory Landscape

Regulations concerning synthetic ingredients in cosmetics vary globally. In regions like the European Union, stringent safety assessments are required before products can be marketed. The Cosmetic Regulation (EC) No. 1223/2009 requires that all cosmetic products undergo safety evaluations and that specific allergens be highlighted on product labels (Wirtu, 2024). Conversely, the United States uses more post-market surveillance, whereby the FDA monitors these products after release into the market. Such a regulatory approach has led to some glaring gaps in consumer protection due to harmful ingredients remaining on the shelves until adverse event reports prove them unsafe (Panico et al., 2019).

 doi:10.20944/preprints202503.0756.v1

8.4. Effective Labeling Practices

Good labeling practice empowers consumers with more awareness to make informed choices about the products they use. Clear ingredient listings, listing allergens and other potential harmful ingredients, are an important part of consumer safety. But misleading claims-often described as "free from"-can confuse by implying a class of synthetic ingredients is bad when that simply is not true (Consumer NZ., 2023). Advocacy groups continue to urge for clearer regulations regarding these claims, so consumers are not misled.

Continuous advocacy for clearer labeling and ingredient transparency is necessary for consumer health protection. Thus, by empowering consumers with knowledge regarding synthetic ingredients and their potential risks, an advocacy organization helps consumers make better choices in the personal care products they choose. With increased awareness and changes in regulations, cosmetics ingredients can be better addressed by consumers to ensure their health and safety.

9. Safer Alternatives

There is an increasing interest in harmless alternatives to these synthetic hazardous ingredients, either natural or organic compounds. Plant-derived ingredients, alongside formulations developed from green chemistry principles, have shown a potential contribution to reducing the respiratory risk of cosmetics by minimizing exposure to toxic inhaled chemicals and improving general product safety.

9.1. Natural Alternatives to Synthetic Ingredients

These ingredients can provide several benefits in cosmetics and reduce health risks. For instance, lavender and rosemary essential oils are effective substitutes for parabens, with good antimicrobial properties that help to conserve the product naturally (Bom et al., 2020). On the other hand, jojoba oil and coconut oil act as excellent alternatives without phthalates, providing moisturizing properties without the risks from such synthetic compounds. Shea butter and beeswax also find their popular natural use as alternatives to synthetic emulsifiers and stabilizers like PEGs (polyethylene glycols) (Bom et al., 2020). These natural ingredients provide similar functional properties but also take part in skin nourishment and hydration.

9.2. Benefits of Organic Ingredients

Organic ingredients contain no synthetic pesticides or inorganic fertilizers, which significantly reduces the rate of allergic incidents or skin irritation. As such, organic skincare products usually contain a higher degree of active compounds than their synthetic equivalents, making them more potent. For a product to be labeled organic, for example, it has to contain at least 95% organic ingredients due to the strict legislation that regulates organic labeling (Hirata et al., 2022). Besides that, organic ingredients contribute to environmentally friendly practices by protecting biodiversity and avoiding pollution linked to conventional farming methods. This addresses consumer interest in cruelty-free and eco-friendly products.

9.3. Green Chemistry Principles

Besides, formulation with the principles of green chemistry further enhances the cosmetic's safety profile. Green chemistry centers around the design of chemical processes that would generate less waste and decreased utilization of hazardous substances. With renewable resources and less hazardous chemical processes, a manufacturing company is assured of formulating cosmetics that, though effective, are not as bad for the environment as would have been previously imagined (BBC Future, 2022).

The shift towards natural and organic alternatives in cosmetics reflects the growing demands of consumers for safer cosmetics. Manufacturers are able to greatly reduce respiratory risks due to synthetic chemicals by including plant-derived ingredients and adhering to green chemistry. This

 doi:10.20944/preprints202503.0756.v1

trend is not only improving the safety of products but also aligns with broader goals of sustainability in the beauty industry (Warner, Cannon and Dye, 2004).

10. Conclusion

The respiratory effects of synthetic cosmetic ingredients are a new area of concern that calls for extensive research and regulation. This review emphasizes the wide use of hazardous ingredients in cosmetic products and possible acute and chronic respiratory functional effects. In particular, children, elderly individuals, and people with pre-existing diseases are especially vulnerable to developing risks and need focused research and protective measures. The switch to safer alternatives with the help of natural and organic ingredients, coupled with advancements in green chemistry, holds potential to lessen inhalation exposure due to cosmetics. Indeed, a collaborative effort from researchers, manufacturers, and regulators in the industry has the potential to yield products that have less harm on health so that consumers have improved respiratory outcomes and there is improved public safety overall. It is expected that future research will bridge some of the existing gaps, particularly with regard to long-term exposure effects and synergistic interactions of synthetic ingredients with environmental pollutants, while helping consumers make better choices and developing sound regulatory frameworks.

References

1. ACCC product safety (2024) *Cosmetic ingredients labelling guide; Retrieved from:https://www.productsafety.gov.au/consumers/use- cosmetic-and-fashion-products-safely/cosmetic-ingredients-labelling-guide, ACCC product safety*.
2. Administration, U.S.A.F. and drug (2022) *Summary of Cosmetics Labeling Requirements; Retrieved from https://www.fda.gov/cosmetics/cosmetics-labeling-regulations/summary-cosmetics- labeling-requirements, FDA*. Available at: http://scioteca.caf.com/bitstream/handle/123456789/1091/RED2017-Eng-8ene.pdf?sequence=12&isAllowed=y%0Ahttp://dx.doi.org/10.1016/j.regsciurbeco.2008.06.005%0Ahttps://www.researchgate.net/publication/305320484_SISTEM_PEMBETUNGAN_TERPUSAT_STRATEGI_MELESTARI.
3. Adrianne Alaba, P.A. et al. (2022) 'Toxic Effects of Paraben and its Relevance in Cosmetics: A Review', *International Journal of Research Publication and Reviews Journal homepage: www.ijrpr.com*, 3(5), pp. 3425–3466. Available at: www.ijrpr.com.
4. Ahmad, S., Nasser, W. and Ahmad, A. (2024) 'Epigenetic mechanisms of alveolar macrophage activation in chemical-induced acute lung injury', *Frontiers in Immunology*, 15(November), pp. 1–12. Available at: https://doi.org/10.3389/fimmu.2024.1488913.
5. Alford, K.L. and Kumar, N. (2021) 'Pulmonary health effects of indoor volatile organic compounds—a meta-analysis', *International Journal of Environmental Research and Public Health*, 18(4), pp. 1–12. Available at: https://doi.org/10.3390/ijerph18041578.
6. Alnuqaydan, A.M. (2024) 'The dark side of beauty: an in-depth analysis of the health hazards and toxicological impact of synthetic cosmetics and personal care products', *Frontiers in public health*, 12(August), p. 1439027. Available at: https://doi.org/10.3389/fpubh.2024.1439027.
7. American Cancer Society (2014) 'Talcum Powder and Cancer', *2017*, pp. 1–3. Available at: https://www.cancer.org/cancer/cancer-causes/talcum-powder-and-cancer.html.
8. Anaphylaxis, A. and (2024) *Cosmetics containing food allergens; Retrieved from:https://allergyfacts.org.au/cosmetics-containing- food-allergens/, Allergy and Anaphylaxis*.
9. Anderson, S.E. and Meade, B.J. (2014) 'Potential Health Effects Associated with Dermal Exposure to Occupational Chemicals', *Environmental Health Insights*, 8(s1), pp. 51–62. Available at: https://doi.org/10.4137/EHI.S15258.
10. Bains, P. and Kaur, S. (2023) 'Silicone in dermatology: An update', *Journal of Cutaneous and Aesthetic Surgery*, 16(1), p. 14. Available at: https://doi.org/10.4103/jcas.jcas_204_22.

 doi:10.20944/preprints202503.0756.v1

11. Balasubramani, G. and J, P.P. (2022) 'Systematic Review on Respiratory Toxicology Caused by Synthetic Air Fresheners', *International Journal for Research in Applied Science and Engineering Technology*, 10(10), pp. 1217–1220. Available at: https://doi.org/10.22214/ijraset.2022.47161.
12. Balwierz, R. et al. (2023) 'Potential Carcinogens in Makeup Cosmetics', *International Journal of Environmental Research and Public Health*, 20(6). Available at: https://doi.org/10.3390/ijerph20064780.
13. Basinas, I. et al. (2017) 'Exposure to inhalable dust, endotoxin, and total volatile organic carbons on dairy farms using manual and automated feeding systems', *Annals of Work Exposures and Health*, 61(3), pp. 344–355. Available at: https://doi.org/10.1093/annweh/wxw023.
14. BBC Future (2022) *Are 'natural' products better than synthetic ones? Retrieved from https://www.bbc.com/future/article/20220614-synthetic-or-natural-which-is-best-for-climate-and- health. .*
15. Blackburn, K. and Green, D. (2022) 'The potential effects of microplastics on human health: What is known and what is unknown', *Ambio*, 51(3), pp. 518–530. Available at: https://doi.org/10.1007/s13280-021-01589-9.
16. Boberg, J. et al. (2010) 'Possible endocrine disrupting effects of parabens and their metabolites', *Reproductive Toxicology*, 30(2), pp. 301–312. Available at: https://doi.org/10.1016/j.reprotox.2010.03.011.
17. Bom, S. et al. (2020) 'Replacing Synthetic Ingredients by Sustainable Natural Alternatives: A Case Study Using Topical O/W Emulsions', *Molecules (Basel, Switzerland)*, 25(21). Available at: https://doi.org/10.3390/molecules25214887.
18. Borgatta, M. and Breider, F. (2024) 'Inhalation of Microplastics—A Toxicological Complexity', *Toxics*, 12(5), pp. 20–23. Available at: https://doi.org/10.3390/toxics12050358.
19. Bornehag, C.G. and Nanberg, E. (2010) 'Phthalate exposure and asthma in children', *International Journal of Andrology*, 33(2), pp. 333–345. Available at: https://doi.org/10.1111/j.1365-2605.2009.01023.x.
20. Braun, J.M., Sathyanarayana, S. and Hauser, R. (2013) 'Phthalate exposure and children's health', *Current Opinion in Pediatrics*, 25(2), pp. 247–254. Available at: https://doi.org/10.1097/MOP.0b013e32835e1eb6.
21. Calvén, J., Ax, E. and Rådinger, M. (2020) 'The airway epithelium—a central player in asthma pathogenesis', *International Journal of Molecular Sciences*, 21(23), pp. 1–29. Available at: https://doi.org/10.3390/ijms21238907.
22. Canada (2020) *Health Canada: Cosmetic ingredient hotlist . Retrieved from https://www.canada.ca/en/health-canada/services/cosmetic-ingredient-hotlist-list-ingredients-cosmetics.html*.
23. Cao, N. et al. (2024) 'Glycolysis mediates the association between phthalate exposure and the prevalence of childhood asthma: The National Health and Nutrition Examination Survey 2009–2018', *Ecotoxicology and Environmental Safety*, 285(May), p. 117088. Available at: https://doi.org/10.1016/j.ecoenv.2024.117088.
24. Cheng, W.H., Chen, Y.C. and Shih, S.Y. (2023) 'Volatile Organic Compound Emissions from Indoor Fragrance Diffusers', *Atmosphere*, 14(6). Available at: https://doi.org/10.3390/atmos14061012.
25. Choi, Y.H. et al. (2023) 'Occupational exposure to VOCs and carbonyl compounds in beauty salons and health risks associated with it in South Korea', *Ecotoxicology and Environmental Safety*, 256(April), p. 114873. Available at: https://doi.org/10.1016/j.ecoenv.2023.114873.
26. CIR (2020) *'Cosmetic Ingredient Review.' Retrieved from CIR website*.
27. Consumer NZ. (2023) *The truth about 'free from' claims on cosmetics. Retrieved from https://www.consumer.org.nz/articles/the-truth-about-free-from-claims-on-cosmetics. Consumer*.
28. Coslaw (2022) *Cosmetics Claims: When can you claim Natural, Organic, Vegan and Non-GMO? — Part II*, *Coslaw*. Available at: https://coslaw.eu/cosmetics-claims-when-can-you-claim-natural-organic-vegan-and-non-gmo-part-ii/.
29. Cosmetic Ingredient Review (2021) *Cosmetic Ingredient Review: Expert Panel Meeting . Retrieved from https://www.cir-safety.org/ingredients*.
30. Cosmetics Europe Annual Report (2011) *Cosmetics Europe: Guidelines on Cosmetic Product Labelling*, *cosmetic Europe*. Available at: https://www.cosmeticseurope.eu/publications-cosmetics-europe-association/annual-reports.html?view=item&id=101.
31. Crosera, M. et al. (2009) 'Nanoparticle dermal absorption and toxicity: A review of the literature', *International Archives of Occupational and Environmental Health*, 82(9), pp. 1043–1055. Available at: https://doi.org/10.1007/s00420-009-0458-x.

 doi:10.20944/preprints202503.0756.v1

32. Cunniffe, G. et al. (2024) 'Is there such a thing as Sensitive Airways-Friendly Fragranced Cleaning Products?', *Journal of Allergy and Clinical Immunology*, 153(2), p. AB191. Available at: https://doi.org/10.1016/j.jaci.2023.11.617.
33. Dahlgren, J.G. and Talbott, P.J. (2018) 'Asthma from hair straightening treatment containing formaldehyde: Two cases and a review of the literature', *Toxicology and Industrial Health*, 34(4), pp. 262–269. Available at: https://doi.org/10.1177/0748233717750982.
34. Davi de Almeida Neto,Dhara Beatriz Souza Boldrin,Elisa Ebner Melchiori,Giovana Zaia Terrengue Martins,Giovanna Aguiar Fasano Soares Vaz dos Santos,João Pedro Negrelli Barbeiro (2007) 'Effect of air pollution on the respiratory system : A review', *InternationalScience Health Journal ofJournal of*, pp. 221–223.
35. Dondi, A. et al. (2023) 'Outdoor Air Pollution and Childhood Respiratory Disease : The Role of Oxidative Stress'.
36. European Chemicals Agency (2021) *'REACH.' Retrieved from ECHA website*.
37. European Commission (2021) *'Cosmetics Regulation (EC) No. 1223/2009.' Retrieved from European Commission website*.
38. European Commission (2023) 'COMMISSION REGULATION (EU) 2023/1545 of 26 July 2023 amending Regulation (EC) No 1223/2009 of the European Parliament and of the Council as regards labelling of fragrance allergens in cosmetic products', *Official Journal of the European Union*, 27.7.2023(2), p. L188/1-L188/23.
39. EWG (2019) *Study: Chemicals in Cosmetics Linked to Lung Damage in Children Retrieved from https://www.ewg.org/news-insights/news-release/study-chemicals-cosmetics-linked- lung-damage-children*, *EWG*.
40. Ezendam, J., Ter Burg, | W and Wijnhoven, | S W P (2011) 'Inhalation exposure to fragrance allergens Are consumers at risk for respiratory allergies?' Available at: www.rivm.com.
41. FDA (2021) *" Cosmetics: Overview " Retrieved from FDA website*.
42. FDA (2022) 'FDA Regulation of Cosmetics and Personal Care Products', pp. 1–30. Available at: https://crsreports.congress.gov.
43. Fendall, L.S. and Sewell, M.A. (2009) 'Contributing to marine pollution by washing your face: Microplastics in facial cleansers', *Marine Pollution Bulletin*, 58(8), pp. 1225–1228. Available at: https://doi.org/10.1016/j.marpolbul.2009.04.025.
44. Fiume, M.M. et al. (2015) 'Safety Assessment of Talc as Used in Cosmetics', *International Journal of Toxicology*, 34(Supplement 1), pp. 66S-129S. Available at: https://doi.org/10.1177/1091581815586797.
45. Gloria Kang GJ, Ewing-Nelson SR, Mackey L, Schlitt JT, Marathe A, Abbas KM, S.S. (2018) 'Nanoparticles, Lung Injury, and the Role of Oxidant Stress', *Physiology & behavior*, 176(1), pp. 139–148. Available at: https://doi.org/10.1146/annurev-physiol-030212-183735.Nanoparticles.
46. De Groot, A.C. (2020) 'Fragrances: Contact Allergy and Other Adverse Effects', *Dermatitis*, 31(1), pp. 13–35. Available at: https://doi.org/10.1097/DER.0000000000000463.
47. Haccuria, A. et al. (2014) 'Exhaled nitric oxide: A biomarker integrating both lung function and airway inflammation changes', *Journal of Allergy and Clinical Immunology*, 134(3), pp. 554–559. Available at: https://doi.org/10.1016/j.jaci.2013.12.1070.
48. Hadei, M. et al. (2018) 'Indoor concentrations of VOCs in beauty salons; Association with cosmetic practices and health risk assessment', *Journal of Occupational Medicine and Toxicology*, 13(1), pp. 1–9. Available at: https://doi.org/10.1186/s12995-018-0213-x.
49. Hantrakool, S. et al. (2022) 'Effects of Particulate Matter on Inflammation and Thrombosis: Past Evidence for Future Prevention', *International Journal of Environmental Research and Public Health*, 19(14). Available at: https://doi.org/10.3390/ijerph19148771.
50. Health Canada (2021) *'Cosmetics.' Retrieved from Health Canada website*.
51. Hellings, P.W. and Steelant, B. (2020) 'Epithelial barriers in allergy and asthma', (January).
52. Hiemstra, P.S. (2013) *Barrier function of airway tract epithelium. PMC3783221. Retrieved from https://pmc.ncbi.nlm.nih.gov/articles/PMC3783221/*.
53. Hirata, D. et al. (2022) 'Natural and organic cosmetics: Beneficial properties for the environment and health', *International Journal of Advanced Engineering Research and Science*, 9(11), pp. 276–281. Available at: https://doi.org/10.22161/ijaers.911.34.

 doi:10.20944/preprints202503.0756.v1

54. Hoet, P.H.M., Brüske-Hohlfeld, I. and Salata, O. V. (2004) 'Nanoparticles - Known and unknown health risks', *Journal of Nanobiotechnology*, 2, pp. 1–15. Available at: https://doi.org/10.1186/1477-3155-2-12.
55. Hoppin, J.A., Ulmer, R. and London, S.J. (2004) 'Phthalate exposure and pulmonary function', *Environmental Health Perspectives*, 112(5), pp. 571–574. Available at: https://doi.org/10.1289/ehp.6564.
56. Ivanova, E. V. et al. (2023) 'Silicones in Cosmetics', *Polymer Science, Series B*, 65(5), pp. 578–594. Available at: https://doi.org/10.1134/s1560090423600201.
57. Jiménez, D. (2024) *81 Allergens Now Mandatory on Product Labels - BeLab Services; Retrieved from:https://www.belabservices.com/en/post/new-eu-cosmetic-regulations-81-allergens-mandatory- product-labels, Lebel service*. Available at: http://scioteca.caf.com/bitstream/handle/123456789/1091/RED2017-Eng-8ene.pdf?sequence=12&isAllowed=y%0Ahttp://dx.doi.org/10.1016/j.regsciurbeco.2008.06.005%0Ahttps://www.researchgate.net/publication/305320484_SISTEM_PEMBETUNGAN_TERPUSAT_STRATEGI_MELESTARI.
58. Jindal, S. (2016) 'Remodeling in asthma and COPD - Recent concepts', *Lung India*, 33(1), pp. 1–2. Available at: https://doi.org/10.4103/0970-2113.173074.
59. Johnson, S. et al. (2022) 'The Effect of Cosmetic Talc Powder on Health', *Indian Journal of Respiratory Care*, 8(1), pp. 18–21. Available at: https://doi.org/10.4103/ijrc.ijrc_24_18.
60. Kang, D.S. et al. (2022) 'Network-based integrated analysis for toxic effects of high-concentration formaldehyde inhalation exposure through the toxicogenomic approach', *Scientific Reports*, 12(1), pp. 1–12. Available at: https://doi.org/10.1038/s41598-022-09673-0.
61. Kauffman, H.M. (2015) *Pulmonary epithelial barrier function: some new players and mechanisms. PMC4747906. Retrieved from https://pmc.ncbi.nlm.nih.gov/articles/PMC4747906/*.
62. Khalid, M. and Abdollahi, M. (2021) 'Environmental distribution of personal care products and their effects on human health', *Iranian Journal of Pharmaceutical Research*, 20(1), pp. 216–253. Available at: https://doi.org/10.22037/ijpr.2021.114891.15088.
63. Khanna, R. et al. (2024) 'Microplastics and Nanoplastics as Environmental Contaminants of Emerging Concern: Potential Hazards for Human Health', *Sustainability (Switzerland)*, 16(19). Available at: https://doi.org/10.3390/su16198704.
64. Kim, D. et al. (2018) 'Air pollutants and early origins of respiratory diseases', *Chronic Diseases and Translational Medicine*, 4(2), pp. 75–94. Available at: https://doi.org/10.1016/j.cdtm.2018.03.003.
65. Kim, H. (2022) *Role of air pollutants in airway epithelial barrier dysfunction in asthma and COPD. ERJ Open Research, 31(163), 210112. Retrieved from https://publications.ersnet.org/content/errev/31/163/210112*.
66. Kim, J.H. et al. (2018) 'Health risk assessment of dermal and inhalation exposure to deodorants in Korea', *Science of the Total Environment*, 625, pp. 1369–1379. Available at: https://doi.org/10.1016/j.scitotenv.2017.12.282.
67. Kohli, R., Mittal, Anu and Mittal, Amit (2024) 'Adverse effects of Cosmetics on the Women Health', *BIO Web of Conferences*, 86, pp. 1–8. Available at: https://doi.org/10.1051/bioconf/20248601026.
68. Kostic, A. and Pharm, M. (2021) 'Silicones in cosmetics and their impact on the environment', *Cos ACTIVE J*, 1, pp. 34–39.
69. Kwon, J.W. et al. (2018) 'Exposure to volatile organic compounds and airway inflammation', *Environmental Health: A Global Access Science Source*, 17(1), pp. 1–8. Available at: https://doi.org/10.1186/s12940-018-0410-1.
70. Lamichhane, G., Acharya, A., Marahatha, R., Modi, B.,Paudel, R.,Adhikari, A.,Raut, B. K.,Aryal, S.,Parajuli, N. (2023) 'Microplastics in environment: global concern, challenges, and controlling measures', *International Journal of Environmental Science and Technology*, 20(4), pp. 4673–4694. Available at: https://doi.org/10.1007/s13762-022-04261-1.
71. Laycock, A. et al. (2020) 'Characterisation of particles within and aerosols produced by nano-containing consumer spray products', *Atmospheric Environment: X*, 8. Available at: https://doi.org/10.1016/j.aeaoa.2020.100079.
72. Lee, Y. et al. (2023) 'Health Effects of Microplastic Exposures: Current Issues and Perspectives in South Korea', *Yonsei Medical Journal*, 64(5), pp. 301–308. Available at: https://doi.org/10.3349/ymj.2023.0048.
73. Leikauf, G.D. and Kim, S. (2020) 'Mechanisms of ultra fi ne particle-induced respiratory health effects', *Experimental & Molecular Medicine*, pp. 329–337. Available at: https://doi.org/10.1038/s12276-020-0394-0.

 doi:10.20944/preprints202503.0756.v1

74. Lesliam Quirós-Alcalá, Nadia N. Hansel, Meredith C. McCormack, E.C.M. (2017) 'Paraben exposures and asthma-related outcomes among children from the US general population', *Physiology & behavior*, 176(1), pp. 100–106. Available at: https://doi.org/10.1177/0022146515594631.Marriage.
75. Leslie, H.A. (2014) 'Review of Microplastics in Cosmetics', *IVM Institute for Environmental Studies*, 476(July), p. 33.
76. Li, Y. et al. (2023) 'Potential Health Impact of Microplastics: A Review of Environmental Distribution, Human Exposure, and Toxic Effects', *Environment and Health*, 1(4), pp. 249–257. Available at: https://doi.org/10.1021/envhealth.3c00052.
77. Lim, S.K. et al. (2010) 'Formaldehyde induces apoptosis through decreased Prx 2 via p38 MAPK in lung epithelial cells', *Toxicology*, 271(3), pp. 100–106. Available at: https://doi.org/10.1016/j.tox.2010.03.011.
78. Liu, T. et al. (2020) 'Ultrasmall copper-based nanoparticles for reactive oxygen species scavenging and alleviation of inflammation related diseases', *Nature Communications*, 11(1), pp. 1–16. Available at: https://doi.org/10.1038/s41467-020-16544-7.
79. Liu, Y. et al. (2022) 'Association between environmental chemicals co-exposure and peripheral blood immune-inflammatory indicators', *Frontiers in Public Health*, 10. Available at: https://doi.org/10.3389/fpubh.2022.980987.
80. Loretz, L.J. et al. (2008) 'Exposure data for cosmetic products: Facial cleanser, hair conditioner, and eye shadow', *Food and Chemical Toxicology*, 46(5), pp. 1516–1524. Available at: https://doi.org/10.1016/j.fct.2007.12.011.
81. Magdalena Fandiño-Del-Rio, Elizabeth C. Matsui, Roger D. Peng,John D. Meeker, L.Q.-A. a (2022) 'Phthalate biomarkers and associations with respiratory symptoms and healthcare utilization among low-income urban children with asthma', *sciencedirect*, pp. 1–26.
82. Makuvara, Z. et al. (2024) 'Unveiling the dark side of beauty? Beauty parlours as potential pollution and human exposure hotspots', *Process Safety and Environmental Protection*, 182(December), pp. 1153–1170. Available at: https://doi.org/10.1016/j.psep.2023.12.045.
83. Manke, A., Wang, L. and Rojanasakul, Y. (2013) 'Mechanisms of nanoparticle-induced oxidative stress and toxicity', *BioMed Research International*, 2013. Available at: https://doi.org/10.1155/2013/942916.
84. McDonald, B.C. et al. (2018) 'Volatile chemical products emerging as largest petrochemical source of urban organic emissions', *Science*, 359(6377), pp. 760–764. Available at: https://doi.org/10.1126/science.aaq0524.
85. Mishra, S. et al. (2019) 'Accidental Acute Talcum Powder Inhalation in an Adult: A Rare Case with a Short Review of Literature', *Indian Journal of Occupational and International Medicine*, 23(1), pp. 8–13. Available at: https://doi.org/10.4103/ijoem.IJOEM.
86. Mittal, M. et al. (2014) 'Reactive oxygen species in inflammation and tissue injury', *Antioxidants and Redox Signaling*, 20(7), pp. 1126–1167. Available at: https://doi.org/10.1089/ars.2012.5149.
87. Mpayipheli, N. et al. (2024) 'Paraben residues in wastewater and surface water: a case study of KwaZulu Natal and Gauteng provinces (South Africa) during the COVID-19 pandemic', *Frontiers in Environmental Science*, 12(August), pp. 1–14. Available at: https://doi.org/10.3389/fenvs.2024.1418375.
88. Mujtaba, S.F. et al. (2021) 'Oxidative-Stress-Induced Cellular Toxicity and Glycoxidation of Biomolecules by Cosmetic Products under Sunlight Exposure', pp. 1–10.
89. Naqvi, S.A.R. et al. (2022) 'Toxicology of Heavy Metals Used in Cosmetics', *Journal of the Chilean Chemical Society*, 67(3), pp. 5615–5622. Available at: https://doi.org/10.4067/S0717-97072022000305615.
90. Nurmatov, U.B. et al. (2015) 'Volatile organic compounds and risk of asthma and allergy : a systematic review', pp. 92–101. Available at: https://doi.org/10.1183/09059180.00000714.
91. Of, L. and Products, C. (2017) 'Annex I , part 7 COSMETIC LABELING REQUIREMENTS', *Guidelines for Control of Cosmetic Products in Malaysia*, (February), pp. 1–4.
92. Oh, H.-J. and Kim, J. (2020) 'Characterization of inhalable aerosols from cosmetic powders and sustainability in cosmetic products', *Sustainability (Switzerland)*, 12(19). Available at: https://doi.org/10.3390/su12198187.
93. Oh, H.J., Han, T.T. and Mainelis, G. (2021) 'Potential consumer exposure to respirable particles and TiO2 due to the use of eyebrow powders', *Journal of Exposure Science and Environmental Epidemiology*, 31(6), pp. 1032–1046. Available at: https://doi.org/10.1038/s41370-020-00278-1.

 doi:10.20944/preprints202503.0756.v1

94. Panico, A. et al. (2019) 'Skin safety and health prevention: An overview of chemicals in cosmetic products', *Journal of Preventive Medicine and Hygiene*, 60(1), pp. E50–E57. Available at: https://doi.org/10.15167/2421-4248/jpmh2019.60.1.1080.
95. Pat, Y. et al. (2024) 'Recent advances in the epithelial barrier theory', *International Immunology*, 36(5), pp. 211–222. Available at: https://doi.org/10.1093/intimm/dxae002.
96. Pneumologia, D. et al. (1996) 'Aging and the respiratory system', 8(3), pp. 143–161.
97. Portugal, J. et al. (2024) 'Toxicity of airborne nanoparticles: Facts and challenges', *Environment International*, 190(April). Available at: https://doi.org/10.1016/j.envint.2024.108889.
98. Preda, O. et al. (2024) 'Health Implications of Widespread Micro- and Nanoplastic Exposure: Environmental Prevalence, Mechanisms, and Biological Impact on Humans', *Toxics* [Preprint].
99. Prodigia Cosmetics (2023) *Allegations and 'claims' in your natural cosmetic products. Retrieved from https://www.prodigia- cosmetics.com/allegations-and-claims-in-your-natural-cosmetic-products/?lang=en.*, *Prodigia Cosmetics*.
100. Rádis-Baptista, G. (2023) 'Do Synthetic Fragrances in Personal Care and Household Products Impact Indoor Air Quality and Pose Health Risks?', *Journal of Xenobiotics*, 13(1), pp. 121–131. Available at: https://doi.org/10.3390/jox13010010.
101. El Refay, A.S. et al. (2024) 'Phthalate Exposure and Pediatric Asthma: A Case Control Study Among Egyptian Children', *Biomedical and Pharmacology Journal*, 17(3), pp. 1489–1498. Available at: https://doi.org/10.13005/bpj/2959.
102. Robert, F.O., Waritimi, G.. and Dare, N.. (2012) 'The historical effects of formaldehyde vapours on the lung', *International Journal of Basic, Applied and Innovative Research*, 7(1), pp. 29–34. Available at: https://www.ajol.info/index.php/ijbair/article/view/174851.
103. Rothe, H. et al. (2011) 'Special aspects of cosmetic spray safety evaluations: Principles on inhalation risk assessment', *Toxicology Letters*, 205(2), pp. 97–104. Available at: https://doi.org/10.1016/j.toxlet.2011.05.1038.
104. Shapypro (2024) *Natural cosmetic and how to claim them ; Retrieved from:https://shapypro.com/natural-cosmetic-and- how-to-claim-them/*, *Shapypro*.
105. Sharma, R. and Kaushik, H. (2021) 'Micro-plastics: An invisible danger to human health', *CGC International Journal of Contemporary Technology and Research*, 3(2), pp. 182–186. Available at: https://doi.org/10.46860/cgcijctr.2021.06.31.182.
106. Siti Zulaikha, R., Sharifah Norkhadijah, S.I. and Praveena, S.M. (2015) 'Hazardous Ingredients in Cosmetics and Personal Care Products and Health Concern : A Review', *Public Health Research*, 5(1), pp. 7–15. Available at: https://doi.org/10.5923/j.phr.20150501.02.
107. Son, E. (2024) 'Air Pollution and Ethical Consumption Behavior Due to Fragrances', *Environmental Research and Technology*, 7(December), pp. 626–636. Available at: https://doi.org/10.35208/ert.1453891.
108. Sonwani, S. et al. (2021) 'Inhalation Exposure to Atmospheric Nanoparticles and Its Associated Impacts on Human Health: A Review', *Frontiers in Sustainable Cities*, 3(August), pp. 1–20. Available at: https://doi.org/10.3389/frsc.2021.690444.
109. Soppa, V.J. et al. (2014) 'Respiratory effects of fine and ultrafine particles from indoor sources-a randomized sham-controlled exposure study of healthy volunteers', *International Journal of Environmental Research and Public Health*, 11(7), pp. 6871–6889. Available at: https://doi.org/10.3390/ijerph110706871.
110. Steinemann, A. (2016) 'Fragranced consumer products: exposures and effects from emissions', *Air Quality, Atmosphere and Health*, 9(8), pp. 861–866. Available at: https://doi.org/10.1007/s11869-016-0442-z.
111. Steinemann, A.C. (2009) 'Fragranced consumer products and undisclosed ingredients', *Environmental Impact Assessment Review*, 29(1), pp. 32–38. Available at: https://doi.org/10.1016/j.eiar.2008.05.002.
112. Subin Paul, G Nancy Angeline, Sakthi Arasu, Don J Maliyakkal, J.C.S. (2023) 'Migrant workers Neurotoxicants / Neurologic disease Occupational epidemiology in unorganised sectors : agriculture , construction , service', *Occup Environ Med*, 80(December 2021), p. 2023. Available at: https://doi.org/10.1136/OEM-2023-EPICOH.69 on 14 March 2023. Downloaded from http://oem.bmj.com/.
113. Thá, E.L. et al. (2021) 'Beyond dermal exposure: The respiratory tract as a target organ in hazard assessments of cosmetic ingredients', *Regulatory Toxicology and Pharmacology*, 124(June). Available at: https://doi.org/10.1016/j.yrtph.2021.104976.

 doi:10.20944/preprints202503.0756.v1

114. Thiriou, D. et al. (2017) 'Innate immunity as the orchestrator of allergic airway inflammation and resolution in asthma', *International Immunopharmacology*, 48(November 2016), pp. 43–54. Available at: https://doi.org/10.1016/j.intimp.2017.04.027.
115. U.S.A. Food and Drug Administration (2022) *Allergens in Cosmetics; Retrieved from:https://www.fda.gov/cosmetics/cosmetic-ingredients/allergens- cosmetics*, *FDA*.
116. Vinnikov, D. et al. (2023) 'Exposure to Respirable Particulate Matter and Its Association with Respiratory Outcomes in Beauty Salon Personnel', *International Journal of Environmental Research and Public Health*, 20(3). Available at: https://doi.org/10.3390/ijerph20032429.
117. Warner, J.C., Cannon, A.S. and Dye, K.M. (2004) 'Green chemistry', in. Available at: https://doi.org/10.1016/j.eiar.2004.06.006.
118. Wirtu, Y.D. (2024) 'A review of environmental and health effects of synthetic cosmetics', *Frontiers in Environmental Science*, 12(October), pp. 1–25. Available at: https://doi.org/10.3389/fenvs.2024.1402893.
119. Yu, Y. and Wang, J.Q. (2024) 'Phthalate exposure and lung disease: the epidemiological evidences, plausible mechanism and advocacy of interventions', *Reviews on Environmental Health*, 39(1), pp. 37–45. Available at: https://doi.org/10.1515/reveh-2022-0077.
120. Yu, Z. et al. (2020) 'Reactive Oxygen Species-Related Nanoparticle Toxicity in the Biomedical Field', *Nanoscale Research Letters*, 15(1). Available at: https://doi.org/10.1186/s11671-020-03344-7.