

Heavy Metals: The Notorious Daredevils of Daily Personal Care Products

Abdul Kader Mohiuddin

Assistant Professor, Department of Pharmacy, World University of Bangladesh, Dhaka, Bangladesh
mohiuddin3@pharmacy.wub.edu.bd

Abstract: Personal care products and facial cosmetics are commonly used by millions of consumers on a daily basis. Direct application of cosmetics on human skin makes it vulnerable to a wide variety of ingredients. Despite the protecting role of skin against exogenous contaminants, some of the ingredients in cosmetic products are able to penetrate the skin and to produce systemic exposure. Consumers' knowledge of the potential risks of the frequent application of cosmetic products should be improved. While regulations exist in most of the high-income countries, in low income countries there is a lack of similar standards. In most countries for which these legal regulations have been identified, restrictions on the permissible level of heavy metals are strict. There is a need for enforcement of existing rules, and rigorous assessment of the effectiveness of these regulations. The occurrence of metals in cosmetic products is of concern for three principal reasons: (i) the use of cosmetic products could represent a possible source of population-wide exposure daily, and often long-term exposure to metals in cosmetic products (ii) metals can accumulate in the body over time, and (iii) a number of them are known to exhibit different chronic health effects, such as cancer, contact dermatitis, developmental, neurological and reproductive disorders, brittle hair and hair loss. Some metals are potent endocrine disruptors and respiratory toxins. Moreover, some metals, such as Cd, As, Pb, Hg and Sb, are exceptionally toxic with a wide variety of chronic health effects, whereas Cr, Ni and Co are well known skin sensitizers. Since the issue of heavy metals as deliberate cosmetic ingredients has been addressed, attention is turned to the presence of these substances as impurities.

Keywords: Heavy Metal Toxicity; Personal care products; endocrine disruptors; Cosmetics Safety; Heavy Metal Contamination; Kohl; Cosmetic Regulation; Cosmetic Impurities

Cosmetics and personal care products are ubiquitous. The US researchers identified some 12500 industrial chemicals used as cosmetic ingredients, includes carcinogens, pesticides, reproductive toxics, endocrine disruptors, plasticizers, degreasers, and surfactants [4-6]. The US FDA estimated 12,500 chemicals used in cosmetics, 20% of them are safe according to CIR review, only 11 of them are banned in US but more than 1300 are banned or restricted in the EU [7-9]. Heavy metals such as lead, mercury, cadmium, arsenic and nickel, as well as aluminum, classified as a light metal, are detected in various types of cosmetics (color cosmetics, face and body care products, hair cosmetics, herbal cosmetics, etc.) [10]. The metals are from the contamination of raw materials and use of sub-standard raw materials, lack of compliance by small scale manufacturers, and lack of strict regulations [11]. Also, Alam et. al, 2019 says many cosmetic products contain heavy metals as ingredients or impurities [12]. Vella et. al, 2019 reported presence of lead in toothpastes were beyond limit of US and EU standards [13]. According to Panico et. al, 2019 PEGs (favorably used as penetration enhancers) may contain residual impurities like lead, iron, cobalt, nickel, cadmium, arsenic [14]. Łodyga-Chruścińska et. al, 2018 detailed nearness of lead and nickel in lipsticks and powders at level restricted by European guideline in Polish market [15]. Applying kajal (otherwise called Kohl or Surma) to infants' eyes is an old custom in numerous societies of the world including Asia, Middle East, European countries, North America and Africa. Kajal or Surma has been

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reported to contain lead and to be a potential source of lead toxicity in children, which can lead to permanent damage to multiple organ systems [16-18]. A similar Nigerian cosmetic called "Tiro" applied to the infant's eyelids contained 82.6% lead which was as high as 70% in Kajal or Surma [19, 20]. Use of eye cosmetics imported from Pakistan was found to be strongly correlated with elevated blood lead levels [21]. Kohl, a type of customary cosmetic product used for eyeliner in the Middle East, contains more than 50% of lead [22]. A similar study with Malaysian eyeshadows shows the same, lead content exceeding limit of international standard [23]. It has been observed that the blood lead level of eye cosmetics consumers in Pakistan, India, and Saudi Arabia in comparison with non-consumers was threefold. Cd and Pb was profound among lipstick samples of Iran and were the most predominant in most Indian cosmetics, along with As [24-26]. Lip cosmetics to the digestive tract damages various vital organs once reaching into systemic circulation [1]. A similar study shows predominance of Hg and Pb among Indian herbal cosmetics exceeding WHO permissible limit. Very high level of trace metals was reported in locally produced facial makeup in Nigeria [27]. Cobalt is a skin allergen responsible for allergic contact dermatitis (ACD), found higher concentration in shampoo than relaxers and conditioners [28]. In individuals with tattoos containing red pigment of the starting point of mercuric sulfur (cinnabar-vermilion, Chinese red), they may encounter irritation that is restricted to this region inside a half year of tattooing [29]. Sindoor, a corrective powder utilized in Hindu religious and cultural ceremonies has hazardous degrees of lead [30]. The highest concentration of Pb was found in nettle, Cd in yarrow, and Hg in horsetail, plants most commonly used in herbal cosmetics of Poland [31]. Henna, a traditional plant product applied as temporary paint-on tattoos and hair dying, is reported to be very rich in heavy metals such as mercury and lead [32]. Saadatzaheh et. al, 2019 reported that arsenic contents of lipsticks, eye shadows, and eyebrow pencils was significantly higher than the BVL (Federal Office of Consumer Protection and Food Safety of Germany) standard [33]. Among the heavy metal impurities, mercury, arsenic, lead, cobalt, antimony, cadmium, nickel and chromium are exceptionally toxic and are prohibited in cosmetics to be included deliberately as ingredients in EU and US [34]. Pb and Cr are the most profound metals in talcum powder samples [35]. According to Health Canada, 100% of all cosmetics product tested positive for nickel and over 90% tested positive for both lead and beryllium and on the average contained at least 4 of the 8 metals of concern (arsenic, cadmium, lead, mercury, beryllium, nickel, selenium, and thallium) [36]. Although titanium's use in sunscreens is regulated, some formulations also include other heavy metals, which are not regulated [37, 38]. Cosmetics use in pregnancy is not uncommon. Schwalfenberg et. al, 2018 reported that prenatal lead exposure is associated with a greater risk of premature delivery, reduced postnatal growth, lower mental growth in childhood, schizophrenia and dementia in adulthood [39]. Even low level of Cd exposure may avert neurodevelopment [40]. Prenatal As exposure has been associated with low growth in utero, low birth weight, head and chest circumference in infants, inflammation and atherosclerotic disease in adults [41]. Also, Li et. al, 2019 reported that heavy metal exposure during fetal period of pregnancy may lead to intrauterine growth retardation [42]. Iron oxides are common colorants in eye shadows, blushes and concealers [43]. Some aluminum compounds are colorants in lip glosses, lipsticks and nail polishes [44]. Aluminum is also used in antiperspirants, sun creams and toothpaste. Chronic disorders currently discussed in connection with aluminum exposure: Alzheimer's disease and breast cancer [45]. The safety assessment by Cosmetic Ingredient Review (CIR) does not include metallic or elemental aluminum as a cosmetic ingredient [46]. Arsenic was known to be poisonous during the Victorian era, but perhaps some women thought that a little bit wouldn't hurt [47]. In addition, some color additives may be contaminated by heavy metals like arsenic, lead and mercury [48]. Heavy metals may be intentionally added to detergents as preservatives, pigments (Pb), skin lightening, as well as antimicrobial agents (Hg) [49]. Significant level of As

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and Hg was reported with Mohammad et. al, 2017 in skin bleaching agents of Caribbean region [50]. As used in skin cream and make-up powder causes skin problems, lung cancer, circulatory and peripheral neuropathy, and increased risk of gastrointestinal and urinary tract malignancies [51,52]. Several recent and older studies reported nephrotic syndrome from repeated exposure of mercury and other heavy metals from skin lightening agent [53-58]. Dental amalgam has been used as a restorative treatment in dentistry for well over 170 years. Even after the last mercury dental amalgam is placed, its toxic legacy will continue for decades, because of its pervasive bioaccumulation in the environment, as reported by Tibau et. al, 2019 [59]. However, mercury is usually added to skin-lightening products due to its whitening effect. Mercury ions replace tyrosinase enzyme anions, which inhibit the formation of melanin and produce the whitening and anti-freckle effects [60]. Sun et. al, 2017 reported that chronic mercury poisoning is associated with irritability, tremor, gingivitis, memory loss, dizziness, insomnia, edema, proteinuria, abdominal pain, nausea, hyperthyroidism, and abortion [61]. Wang et. al, 2018 suggested that cumulative exposure to heavy metals as mixtures is associated with obesity and its related chronic conditions such as hypertension and T2DM [62]. Lead poisoning leads to anemia due to jeopardized heme synthesis and acts as a potent reversible and selective blocker of voltage-dependent calcium channels at low concentrations [63,64]. Severe damage to the brain and kidneys, both in adults and children, were found to be linked to exposure to heavy lead levels resulting in death [65-75]. In pregnant women, high exposure to lead may cause miscarriage [76-81]. Men exposed to lead mainly from hair colorants [82-85]. Chronic lead exposure was found to reduce fertility in males [86-89]. The 2017 US FDA safety recall to discontinue using Magellan Diagnostics' Lead-Care Testing Systems for analyzing venous blood samples also highlighted the need for improved blood lead testing and surveillance [90]. Ettinger et. al, 2019 reported that economic benefit of lowering lead levels among children by preventing lead exposure has been estimated at \$213 billion per year [91]. Childhood lead poisoning prevention programs can effectively utilize Medicaid data to increase testing and improve blood lead surveillance [92]. Various sources of acquaintance to chromium exist; including lipstick, eye pencil, eyeliner, eyeshadow, and makeup powder [93, 94]. Cr exists in two valence states, and both oxidation states, i. e. Cr³⁺ and Cr⁶⁺ can act as potential haptens causing ACD and skin ulcers [95-99]. Chromium ACD can be a chronic debilitating disease, perhaps because chromium is difficult to avoid. Toxic metals (cadmium, cobalt, copper, nickel and lead) from body cream basically moisturizers and skin-lightening (toning/bleaching) creams [100]. An increase in level of cadmium has been reported to inhibit DNA repair including mismatch, base excision, and nucleotide excision [101]. Zinc has been reported to cause the same signs of illness as does lead, and can easily be mistakenly diagnosed as lead poisoning [102]. Excess zinc exposure may induce toxic effects on the hematopoietic system, biochemistry and endocrine system function [103]. Skin care experts in the US reckon copper will be this decade's most prominent anti-aging ingredient [104]. Copper delivery through skin can provide beneficial effects but its potential to induce skin irritation reactions is often overlooked [105]. Cobalt and nickel metals commonly found in lipstick, eyeshadow, face paint and hair cream associated with contact dermatitis. Cobalt and its salts are widely used as coloring agents in makeup and light-brown hair dyes [31]. Nickel compound exposure can lead to nephrotoxicity, skin irritation and hypersensitivity [106]. Cobalt chloride has a hazard rank of 9 in the Environmental Working Group (EWG) Skin Deep Database and is banned for use in cosmetics by the EU. Since cobalt and nickel are almost always found together, it is wise to avoid both metals [107]. Literature data show that in commercially available cosmetics have potentially toxic metals that may cause danger to human health. This is coupled with prolonged duration of contact, which may occur due to repeated use of the products. There's an old saying that "A thing of beauty is joy forever". But it should be imparted through avoiding beasts inside the beautification.

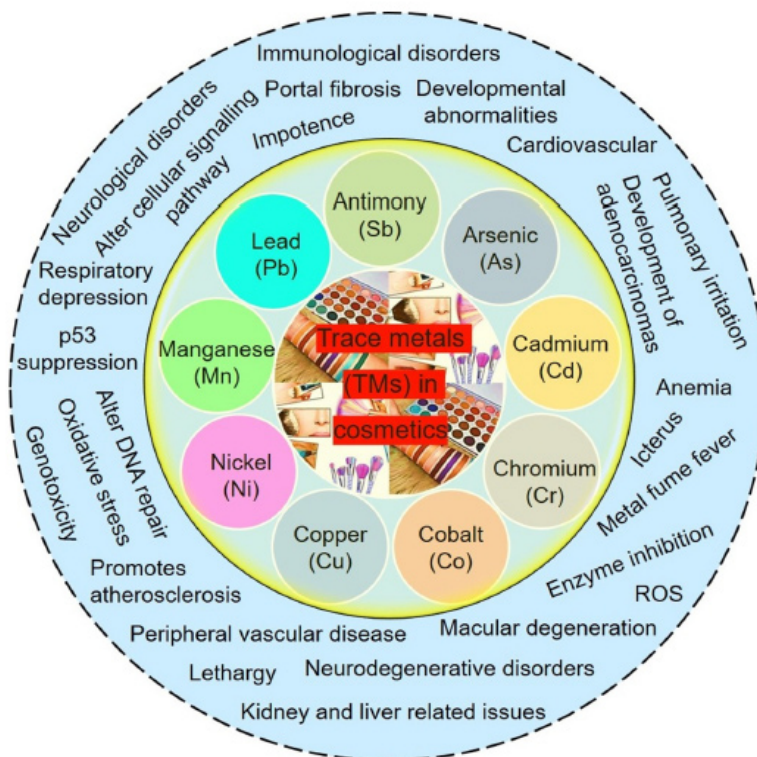


Fig1. Several Untoward Effects Exerted by Heavy Metal Exposure from Cosmetics [1-3].

The global cosmetic products market was valued at USD 382.3 billion in 2010, 532.43 billion in 2017, and is expected to reach a market value of USD 805. 61 billion by 2023, registering a Compound Annual Growth Rate (CAGR) of 7.14% during 2018-2023. Social media is key to the shift in consumer demand. Trends are shared more quickly and emotively, with celebrities and influencers — as well as everyday people — posting content which urges everyone to become a conscious consumer. The presence of heavy metals and xenobiotics are not normally considered as a primary concern in cosmetics. With many new products released into the market every season, it is hard to keep track of the safety of every product and some products may carry carcinogenic contaminants, while some others raise many more detrimental issues.

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ABBREVIATIONS

Compound Annual Growth Rate (CAGR); allergic contact dermatitis (ACD); Cosmetic Ingredient Review (CIR); Type-2 Diabetes Mellitus (T2DM); Environmental Working Group (EWG)

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