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Short Communication

Risk assessment of heavy metals in brands of lipsticks commonly used in Shahrekord, Iran

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Abstract
The desire for beauty and frequent use of cosmetics can expose humans to heavy metals, which can cause immune system disorders over time. We selected 5 common lipstick brands to determine the concentrations of cadmium (Cd), lead (Pb), and chromium (Cr). We prepared each sample by acid digestion, and then the concentration of the metals was measured using an atomic absorption spectrometer. The results showed that Pb, Cd, and Cr were present in all lipstick samples. However, their concentrations were lower than the Food and Drug Administration (FDA) standards. The maximum concentrations of Pb and Cd were 2.31 mg/kg (brand A) and 0.037 mg/kg (brand D), respectively. Health risk assessment of the examined metals showed that only Cr can pose non-carcinogenic (14.98) and carcinogenic (44.96E-04) risks to consumers. Despite the low concentration of heavy metals in our study, chronic use of lipstick can pose carcinogenic and non-carcinogenic risks due to the presence of Cr.
Keywords: Cadmium, Chromium, Heavy metals, Lead, Lipstick, Risk assessment

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Introduction

Exposure to contaminants such as heavy metals through water, air, food, and many cosmetic products can lead to human poisoning (1). If heavy metals accumulate in soft tissues, the body cannot metabolize them, which can cause complications and irreversible effects on the body (2). Dermal contact is the main route of exposure to heavy metals in cosmetics. Oral exposure may occur when they are used around the mouth as well as from hand to mouth contact after exposure to cosmetics containing impurities such as heavy metals (3).

The desire for beauty in humans has led to the frequent use of cosmetics worldwide. Although the skin protects against external contaminants, some cosmetics can pass through the skin, leading to adverse health effects (1). Studies show that a woman inadvertently eats 1.8 kg of lipstick during her lifetime, and direct oral ingestion exacerbates the negative effects of chemicals such as heavy metals (4).

Exposure to lead (Pb) through skin contact can lead to effects such as endocrine disruption, impaired heme synthesis, and blood and renal diseases. Additionally, long-term exposure to chromium (Cr) through the skin or mucosa can cause cancer (5). Cadmium (Cd) is used as a pigment in many cosmetic products due to its color properties, which can accumulate in many organs and cause nausea, vomiting, cramps, abdominal pain, diarrhea, and tension (6). A study has highlighted the importance of investigating the concentration of heavy metals in cosmetics (2). The responsible regulatory agencies, the Ministry of Health, and the government should undertake human health risk assessment of cosmetic products. Improper use of cosmetics, reduction in the age of using cosmetics regardless of their standard, smuggling, and development of counterfeit products can affect people's general health, especially women. Therefore, in this study, we determined the levels of Pb, Cr, and Cd in some lipsticks commonly used in Shahrekord and investigated their health risks.

Materials and Methods

Sample collection

In this study, we collected 50 samples of 5 lipstick brands available in the markets of Shahrekord using the cluster random sampling method. According to the suggestion of big cosmetics sellers, we selected the most known, popular, and best-selling brands produced in Iran, Italy, and the United States.

Sample preparation

The samples were placed in a porcelain crucible and were dried in an oven for 12 hours to reach a constant weight. Then, HNO3 (65 %, Merck, Germany) was added to a certain amount of lipstick (1 g) and heated on a hot plate until near dryness. After cooling the samples, HClO4 (70%-72%, Merck, Germany) was added and heated until the end of the digestion process (appearance of white fumes) and before complete drying. Then, dilution was

done with HNO3 and filtered using 0.45 µm Whatman filter paper (4). Concentrations of Pb, Cr, and Cd (mg/kg) were measured at operating conditions by an atomic absorption spectrometer (Varian 220 z). We also analyzed the data using SPSS version 23.0. *P*-value was considered significant at $P<0.05$.

Health risk assessment

The heavy metal content of lipsticks enters the human body through dermal contact. The risk of chronic daily intake (CDI) of lipsticks through skin contact is calculated according to the following equation:

$$CDI_{dermal} = \frac{CS \times SA \times AF \times ABS \times EF \times ED \times CF}{BW \times AT}$$

Where CS represents the metal concentration in lipsticks (mg/kg), SA is the exposed skin area (5700 cm^2), AF is adherence factor (0.07 mg/cm^2), ABS is dermal absorption fraction, EF is exposure frequency (350 day/year), ED is exposure duration (30 years), BW is body weight (70 kg), AT is average time for non-carcinogens, and CF is the conversion factor (10^{-6} kg/mg).

Non-carcinogenic health risk of exposure to heavy metals through different ways is defined as hazard quotient (HQ). Based on the HQ = CDI/RFD equation, the dermal reference doses (RFD) for Pb, Cd, and Cr are 0.04, 0.001, and 0.000015 mg kg^{-1} day^{-1}, respectively. If $HQ>1$, there is a potential risk to the health of exposed individuals. If $HQ<1$, there are no noticeable adverse effects on the exposed population (7).

Additionally, the carcinogenic risk value is calculated using the following equation:

$$Carcinogenic\ risk\ (CR) = CDI \times SF$$

Where SF is the slope factor of hazardous substances (mg kg^{-1} d^{-1}). According to the USEPA database (2015), the dermal SF for Cr is 2×10^{1} mg kg^{-1} d^{-1}. Dermal slope factor (SF) for Pb and Cd is not available. The CR values of 10^{-6} to 10^{-4} are considered acceptable cancer risk, and $CR<10^{-6}$ is considered negligible. However, $CR>10^{-4}$ indicates a significant cancer risk (7).

Results

This study showed that Pb, Cd, and Cr were present in these samples, even in Pb-free lipsticks. The heavy metal contents in lipsticks were arranged in decreasing order as follows: Cr > Pb > Cd. However, the average concentration of these metals was lower than the FDA's standards for cosmetics (8). The chronic daily intake values and non-carcinogenic risk related to Pb, Cd, and Cr were calculated. According to the results, the HQ value for Cr was above 1, which indicates a significant non-carcinogenic risk to consumers of this product. The non-carcinogenic risks associated with Pb and Cd were negligible. Moreover, the calculated CR value for Cr was higher than 10^{-4}, which indicates a high carcinogenic risk to consumers of this product (Table 1).

According to Figure 1, the maximum amount of Pb was found in brand A with a concentration of 2.31 mg/kg, and the minimum amount of Pb was observed in brand E with an average concentration of 0.251 mg/kg. Brand D had a maximum concentration of Cd (0.037 mg/kg), and the minimum value with a concentration of 0.019 mg/kg was observed in brand B. The maximum and minimum Cr concentrations belonged to brands A and D, respectively.

Discussion

Cosmetics may be contaminated with heavy metals through impurities in ingredients, the manufacturing process, or migration from packaging (7). Every year, different cosmetics and health products with different brands enter the country, and the concentration of metals in cosmetics is also different from each other (4). This study showed that Pb, Cd, and Cr concentrations in lipsticks sold in Shahrekord were lower than the FDA standards, although present in all samples. Heavy metals present in cosmetics are indeed synthetic dyes with a mineral structure, such as mica (9). Arshad et al reported that concentrations of heavy metals in lipstick samples were lower than the FDA standards, consistent with the results of this study (2). Similarly, Zainy et al reported that Pb and Cd contents in lipstick products in Jeddah were below the recommended limits (3). In another study, Malakotian et al reported that the average Pb concentration in 27 types of solid lipsticks and 9 types of liquid lipsticks was 523.4 µg/g and 3.3 µg/g, respectively. These results differed from the results of our study (10).

Health risk assessment of heavy metal exposure through the use of lipsticks indicated that Cr had a non-carcinogenic risk. Moreover, there was no non-carcinogenic risk of Pb and Cd in lipsticks. The results of the study by Mansouri et al showed that the HQ value for Pb and Cd in hair dyes and lipsticks was less than 1 (11). Our findings showed that exposure to Cr through the use of lipstick can pose a carcinogenic risk to consumers. Contrary to the results of our study, Alam et al showed that the cancer risk of Cr from dermal exposure to beauty cream was lower than the negligible range (7). The results of the study by Nduka et al showed that carcinogenic and non-carcinogenic risks associated with the use of cosmetic brands in Nigeria were unlikely (9). Similar to the results of our study, Malvandi and Sancholi revealed that the HQ values for Pb and Cd were < 1, while the HQ value for Cr was > 1 in three brands (5).

Cr can cause severe skin allergies. Acute contact with Cr can lead to severe corneal damage, deep skin burns, as well as oral and esophageal burns (12). Massadeh et al demonstrated that heavy metals such as Cr can pose a risk in daily use and oral consumption, even at concentrations below the permitted level (13). In a similar study, Nnorom et al reported that the concentration of Cd in cosmetics was 1 µg/g (14). In another study, Nourmoradi et al reported that the average concentration of Cd in 7

Table 1. Mean concentration (mg/kg of dry weight) of Pb, Cd, and Cr in lipsticks and their non-carcinogenic and carcinogenic risks

		Sample size	Pb	Cd	Cr
Sample code	A	10	2.312	0.022	3.373
	B	10	0.470	0.019	0.305
	C	10	1.395	0.025	1.381
	D	10	0.552	0.037	0.094
	E	10	0.251	0.0242	2.192
	Mean ± SD	50	0.996 ± 0.854	0.0255 ± 0.007	1.47 ± 1.36
	Reference values* (8)	-	20	5	10-20
Health risk assessment	CDI	50	15.23E-05	3.89E-06	22.48E-05
	HQ	50	0.003807	0.0390	14.98
	CR	50	-	-	44.96E-04

CDI: chronic daily intake, HQ: hazard quotient, CR: carcinogenic risk
* The FDA's standards for heavy metals in cosmetics

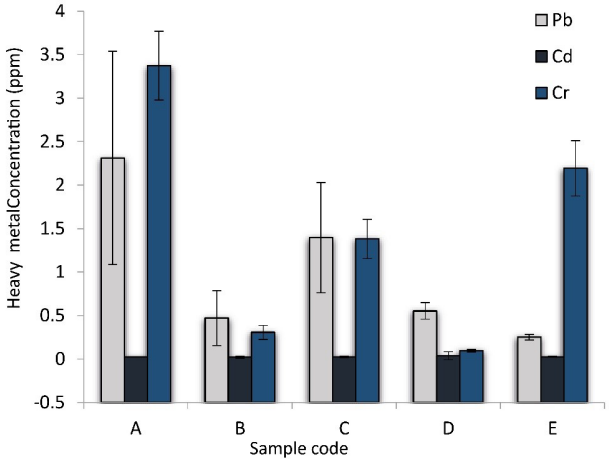

Figure 1. Comparison of the mean levels of Pb, Cd, and Cr in different lipstick brands

brands of lipstick ranged from 4.08 to 60.20 µg/g, which was higher than the average concentration obtained in this study (15).

Though the concentration of Pb in lipstick samples was lower than the concentration recommended by the FDA, the degree of toxicity of heavy metals to humans depends on their daily intake (7). Today, the use of this cosmetic product in modern societies is increasing, and the age of using this type of product is decreasing. Licking the lips, eating, and drinking while wearing lipstick will lead to ingestion of the lipstick components (4). Cd is used as a pigment in the production of lipstick. Its dermal absorption is low (0.5%), and its absorption through ingestion is about 6%, but it is toxic even at low levels. Prolonged exposure to Cd can lead to dysfunction of the kidneys, bones, and respiratory system. Overexposure to Cd can lead to obstructive pulmonary disease and pneumonitis and has been identified as a mutagen and reproductive toxin. In a previous study, Cd toxicity affected women more than men (6). Given that the use of cosmetics among women is more common, long-term exposure to Cd, even in small amounts, puts this group at greater risk.

Conclusion

In this study, we determined Pb, Cd, and Cr concentrations in 5 brands of lipsticks sold in Shahrekord. Although the concentration of these metals in the studied lipsticks was below the limits set by the FDA, the health risk assessment of heavy metals showed that Cr can pose carcinogenic and non-carcinogenic risks to consumers. Because significant amounts of Pb, Cd, and Cr can be absorbed through the skin, the entry of these metals into the body through lipstick is undeniable. The accumulation of these metals and the increased use of these cosmetics among consumers can lead to health concerns, especially for children and pregnant women.

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Authors' Contribution

Conceptualization: Abbas Khodabakhshi, Farideh Bagherzadeh.
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Writing–review & editing: Abbas Khodabakhshi, Farideh Bagherzadeh.

Competing Interests

The authors declare that they have no conflict of interests.

Ethical Approval

The study was approved by the Ethics Committee of Shahrekord University of Medical Sciences, Shahrekord, Iran (IR.SKUMS.REC.1397.173).

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