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Assessment of Heavy Metals Contamination in Lipsticks Available in Bangladeshi Market and Associated Human Health Risk

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Abstract
Contamination of toxic heavy metals in lipstick is of serious concern and requires careful inspection owing to the ability of these metals to accumulate in the skin that may result in subsequent health hazards. The purpose of this study was to assess the concentration of heavy metals (lead, cadmium, and chromium) in lipsticks sold in the Bangladeshi markets, as well as to assess the possible health risks associated with everyday exposure to heavy metals in lipsticks. A total of 48 lipstick samples were purchased from local markets consisting of 12 different brands. The samples were microwave digested before being examined with the Flame Atomic Absorption Spectrophotometer (FAAS). The range of the Pb, Cr and Cr concentration in the brands analysed ranged from 0.054 - 6.557, 0.667 - 2.344, and 0.001 - 0.196 mg.kg-1 (ww), respectively. The mean (± SD) lead, chromium, and cadmium concentrations in all lipstick samples were 2.120 (±1.336), 1.417 (±0.785), and 0.028 (±0.041) mg.kg-1 (ww), respectively. The amounts of lead and chromium were significantly different amongst brands (p 0.05). The concentrations of lead and cadmium were below the acceptable limit set by Health Canada and the European Union (EU). However, chromium exceeds the maximum allowable concentrations set by the EU. Results from Hazard Quotient (HQ) indices represent no non-carcinogenic health risk (HQ < 1) to consumers. But the values of Relative Intake Index (RII) indicate some health risks in terms of Cd and Cr concentrations of some lipstick brands found in Bangladeshi markets. Furthermore, a parallel use of lipstick with other cosmetics could be detrimental for Bangladeshi people, and, therefore, a continuous monitoring to curb such adulterated daily products is urgently needed.

Keywords: Toxicity, Health risk assessment, Cosmetics, Bangladesh.

Introduction
The worldwide consumption of beauty products has risen at an unprecedented pace because of the never-ending pursuit of human adornment (Gondal et al., 2010). One of the major concerns with cosmetic products is the presence of high levels of impurities and heavy metals (Al-Saleh and Al-

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Enazi, 2011; Zainy 2017; Zakaria and Ho, 2015). Lipsticks have long been a concern for public health because of the potential health hazards, most particularly, due to continuous exposure of high levels of impurities and heavy metals from dermal contact and oral ingestion (Pinto et al., 2018; Wang, et al., 2008). Usually, lipstick is applied on the lips to make them more appealing and glamorous, but the price of this practice results to the exposure of heavy metals found in the lipstick items. The presence of heavy metals, such as lead, cadmium, and chromium, have already been detected in lipsticks (Al-Saleh and Al-Enazi 2011; Malvandi & Sancholi, 2018; Zakaria & Ho, 2015). Fortunately, lipstick consumers are only exposed to heavy metals in limited amounts, but they are exposed to chronic health risks over a long-time period, which makes them notable (Zakaria & Ho, 2015). When customers eat and drink, a minuscule amount of lipstick can be swallowed, resulting in exposure to a minuscule amount of lipstick (Gondal, et al., 2010). It has been estimated that a woman advertently ingests1.8 kg of lipstick during her lifetime (The Campaign for Safe Cosmetics, 2007).

Lead is one of the heavy metals significantly present in lipsticks (Abbasi et al., 2011). Developmental neurotoxicity, teratogenic effects in young children, cardiovascular effects, nephrotoxicity, and reproductive effects in adults have been identified as critical effects of lead poisoning (CONTAM, 2010; Koller et al., 2004; Piccinini et al., 2013). Lead can cross the placenta during pregnancy and trigger premature birth and produces low birth weight (Sainio et al., 2000). Chromium found in lipstick is also corrosive, and large amounts of chromium can trigger stomach upset, ulcers, seizures, damage to the kidneys and liver, and even cause death (Baruthio, 1992; Gondal et al., 2010; Wilbur et al., 2012). As a result of the chromium's harmful effects on the skin, ulcerations, dermatitis, and allergic skin reactions characterized by excessive redness and swelling of the skin have been recorded (Alam et al., 2019). Cadmium is used in lipsticks as colour pigment and the absorption through the skin is low (0.5%). Long-term cadmium exposure has been related to diabetes, cardiovascular disorders, like atherosclerosis, and hypertension (Alissa & Ferns, 2011; Keli et al., 2013). Sensitivity to heavy metals can often establish carcinogenic health risks for users of lipsticks, in addition to the non-carcinogenic chronic health dangers. There is ample evidence of cadmium contamination through inhalation and intramuscular and intravenous injection in rats and mice, but no proof of carcinogenic reaction through ingestion has established (U.S. EPA, 1991).

The use of cosmetic items by Bangladeshi women is an old practice. They use cosmetics as an aid to enhance their appearance and conceal skin blemishes. Bangladesh's Environment and Social Development Organization (ESDO) reported that Bangladesh's manufactured and exported beauty goods contain far too many toxic chemicals that are hazardous to human health and the environment. A study conducted on commonly used cosmetics in Bangladesh found a high concentration of lead, cadmium, and chromium, which is even higher than the acceptable limit set by the World Health Organization (WHO) (Alam et al., 2019). However, no comprehensive research has published about the heavy metal concentration in lipstick products found in Bangladesh.

As the popularity of lipsticks grows in Bangladesh, several chemicals, including heavy metals, are employed in lipsticks, putting users' health at danger. To the best of the researchers' knowledge, this is the first attempt in Bangladesh to study the heavy metal content of lipstick samples and to determine the potential risk assessment for health. The objective of this study was to determine heavy metals, like lead (Pb), cadmium (Cd), and chromium (Cr) in some lipstick samples available in the Bangladeshi local market and health risk assessment of these samples.

Materials and Methods

Sample Collection

The lipstick samples were purchased from the local market and franchise stores in Dhaka city, Bangladesh (Figure 1). The samples were of different qualities and popular brands with different price ranges. Twelve lipstick brands were selected, and four samples from the respective brand were purchased. The samples were coded from A to L in order to mask the brand names. The colour of all samples and their manufacturing identity and expiry date also mentioned. The particulars of the samples are presented in Table 1.

Figure 1: Sampling areas for lipstick samples**.**

Chemicals and standards

Reference standard heavy metals, such as Pb, Cd, and Cr, were purchased from Kanto Chemical Co. Inc. (Tokyo, Japan). Chemicals used for digestion of the samples (65% nitric acid (HNO_3) and 30% hydrogen peroxide (H_2O_2)) were of analytical grades and they were purchased from Merck (India). Single element standard solutions (Perkin-Elmer & Co, GmbH, Germany) at the concentration of 1 mg.mL^{-1} were used to prepare calibrates and internal standards (ISs). All the ISS were at the concentration of 1 ng.mL^{-1} in the analytical solutions. Freshly prepared double deionized distilled water generated through three steps, such as distillation, deionization, and ultra-purification, was used for diluting samples and standards to prevent contamination.

Table 1: Description of the collected lipstick samples

Serial No	Lipstick Brands Code	Colour	Manufacturing date	Expiry date
1	A	Chocolate	June 2019	November 2020
2	B	Orange	July 2019	January 2021
3	C	Purple	January 2020	June 2021
4	D	Red	August 2019	July 2021
5	E	Matte brown	January 2019	May 2020
6	F	Pink	January 2019	June 2021
7	G	Brown	June 2018	November 2020
8	H	Russet	August 2018	July 2020
9	I	Matte pink	January 2017	May 2021
10	J	Black	January 2018	June 2020
11	K	Rose	June 2019	November 2021
12	L	Glossy blue	January 2018	May 2020

Sample preparation

After drying at 80 °C for 24 hours, the lipstick samples were powdered. The lipstick samples were dried and then powdered. 1.0 g of lipstick sample was being weighed and then placed into a 100 ml Pyrex glass beaker. Then 10 ml of concentrated nitric acid (65%) was added to it. Then 5 ml of concentrated hydrogen peroxide (30% H_2O_2) was added to the mixture. After that, the mixture was placed on a hot plate at 180°C. The solution was reduced to 5 ml and kept for cooling until reaching the room temperature. Then 100 ml of doubly distilled water was being measured with a measuring cylinder and made a solution with the residue. The residual material was diluted with deionized water to the final volume of 100 ml. The solution was then filtered by Whatman filter (Merck, 0.45 μm) (Nnorom et al., 2005). The Flame Atomic Absorption Spectrophotometer (FAAS) (SHIMADZU, AA-7000) at Wazed Miah Science Research Centre (WMSRC) of Jahangirnagar University was used to assess the concentration of metal ions in the solution. Detection limits were 0.1, 0.02, and 0.3 mg.kg^{-1} for lead, cadmium, and chromium, respectively.

The measurement wavelengths for different heavy metals were as follows: Cd (228.67 nm), Cr (357.65 nm), and Pb (217.35 nm). Each sample was analysed in triplicate, and two blanks were also run for each determination. For the preparation of the calibration curve, standard solutions of each metal solution were prepared at six different concentrations (0.0, 0.1, 1.0, 5.0, 10.0, 20.0, and 40.0 µg/L). Assessment of contamination and reliability of data was done as part of the quality control measure. To prevent contamination, samples were usually carefully handled. A recovery analysis was used to validate the metal analysis method, and the percentage recoveries were obtained using the equation below:

$$\text{Percentage recovery} = \frac{CE}{CM} \times 100$$

Where CE is the experimental concentration that was determined by using the calibration curve and CM is the spiked concentration. Percentage recovery values were 90 to 108% for the studied elements.

Quality assurance

Assessment of contamination and reliability of data was done as part of the quality control measure. In general, samples were carefully treated to prevent contamination. The instrument readings were corrected using reagents blank determinations. The standard addition method was used to verify the analytical process (Ullah et al., 2017). Analytical grade chemical reagents were used and various metal stock solutions were prepared from high purity compound (99.9%). Freshly prepared double deionized distilled water was used to prevent contamination.

Health risk assessment

Hazard Quotient and Hazard Index: Health risks for lipstick consumers were obtained based on HQ, which was estimated by using the following formula (Cherfi et al., 2015; Islam & Ahmed, 2015):

$$\mathrm{HQ} = \frac{\mathrm{ADD_{ing}}}{\mathrm{RfD}}$$

ADD_{ing} is the average daily dose, and RfD is the reference dose. Lead, cadmium, and chromium have RfD values of 0.004, 0.001, and 0.003 $mg.kg^{-1}.day^{-1}$, respectively (U.S. EPA, 1998; U.S. EPA, 1991). If the HQ values are less than one, there are no potential harmful impacts; if the HQ values are larger than one, there are adverse health effects. The average daily dose (ADD_{ing}) was determined using the equation below (Miguel and Charlesworth, 2007; U.S. EPA, 1997):

$$\mathrm{ADD_{ing}} = \frac{\mathrm{EFr \times ED \times IR \times C}}{\mathrm{BW \times AT}} \times \mathrm{CF}$$

Where ADD_{ing} denotes the average daily dose (ADD) of ingestion ($mg.kg^{-1}.day^{-1}$); C ($mg.kg^{-1}$) stands for the concentration of heavy metals in the lipstick to which the subject is exposed; IR is the intake rate of the lipstick (Zakaria & Ho, 2015); BW represents the bodyweight of the exposed population; EFr represents the exposure frequency; ED denotes the duration of exposure (35 years, based on the maximum duration of the exposed population); AT denotes the averaging time (days) (ED years × 365 days $year^{-1}$), and CF represents the conversion factor (10^{-3}). Table 2 provides a comprehensive description of each parameter.

The hazard index (HI) is the sum of HQ of individual metal in each food item. The HI assumes that exposure to multiple metals results in additive effects. For the estimation of the total risk of the elements tested, the health risk index (HI) was used. The formula used to calculate this index is as follows:

$$\mathrm{HI} = \sum \mathrm{HQ}$$

Even if the individual HQs for the metals are lower than 1 individually, adverse health effects may be posed by the cumulative effect of ingestion. When the HI is > 1, this entails significant non-carcinogenic risk.

Relative intake indices and estimated daily intake: The following formula was used to determine the relative intake indices (RIIs):

$$RII\ (\%) = \frac{EDI}{PDE} \times 100$$

Here, PDE stands for permissible daily exposure, and EDI is an abbreviated form of estimated daily intake based on the formula below. Lead, cadmium, and chromium have PDE values of 5.0, 5.0, and 10.700 g.day^{-1}, respectively (EMA, 2019; Malvandi and Sancholi, 2018). Using the following formula, the EDI value was calculated:

$$EDI = C \times MIL$$

Again, C is the concentration of the metal content in the lipstick (μg.g^{-1}), where EDI is in micrograms per day, and MLI is the mass of the ingested lipstick (0.04 g.day^{-1}).

Statistical analysis: Statistical Package for the Social Sciences (SPSS) version 22 was used to analyse the results. At a significance level of p 0.05, a One-Way Analysis of Variance (ANOVA) was conducted to analyse the differences in heavy metal concentration among different lipstick brands. For the elements examined, the concentrations are given in milligrams per kilogram (mg.kg^{-1}) of wet weight.

Table 2: Metal exposure parameters in cosmetic samples utilized in the research

Exposure factor	Unit	Value
Exposure frequency (EFr)	Days.year^{-1}	260
Exposure duration (ED)	year	35
Intake rate (IR)	mg.day^{-1}	40
Body weight of the exposed population (BW)	mg.kg^{-1}	60
Average time for non-carcinogens (AT)	days	21,600
Conversion factor (CF)	kg.mg^{-1}	10^{-3}

Results

The concentrations of heavy metals in different lipstick brands are summarized in Table 3. The concentrations of three heavy metals, lead, cadmium, and chromium. The concentrations of three heavy metals, lead, cadmium, and chromium, in lipstick brands ranged from 0.054 to 6.557 mg.kg-1 (ww), 0.001 to 0.196 mg.kg^{-1} (ww), and 0.667 to 2.344 mg.kg^{-1} (ww), respectively. The highest concentrations of lead (Pb) and cadmium (Cd) were observed in brand D, and the highest and lowest concentrations of chromium (Cr) were found in brand I and brand C, respectively. While brand C has the lowest Pb concentration, brand H has the lowest Cd concentration. The mean (± SD) concentration of Pb, Cd and Cr were 2.120 (± 1.336), 0.028 (± 0.041), and 1.417 (± 0.785) mg.kg^{-1} (ww), respectively. One-way ANOVA testing revealed that the amounts of Pb and Cr in different brands differed significantly (p 0.05; Table 4). The ADD, HQ, and HI for all lipsticks are summarized in Table 5. The ADD values were 0.408×10^{-3} to 1.626×10^{-3}, 0.237×10^{-5} to 3.752×10^{-5} and 0.321×10^{-3} to 1.113×10^{-3} for lead, cadmium and chromium, respectively. For lead, cadmium, and chromium, The HQ index values were 0.102 to 0.407, 0.002 to 0.038, and 0.107 to 0.371, respectively. The HQ of lead, cadmium, and chromium in all of the lipstick samples was less than one, indicating that there was no significant non-carcinogenic health risk for lipstick users. The HI index ranged from 0.230 to 0.865 with a mean value of 0.495. Based on the ICH Q3D Guideline health risk assessment was also conducted for the elements studied. Table 6 shows the daily estimated intake (EDI) and relative intake index (RII) for Pb, Cd, and Cr. The highest EDI values for Pb, Cd, and Cr were 0.165, 0.003, and 0.094, respectively, whereas the lowest EDI values for Pb, Cd, and Cr were 0.034, 0.000, and 0.027. The relative intake index (RII) for Pb was the highest, whereas Cd was the lowest (Table 6).

Table 3: Estimated heavy metal content (mg.kg^{-1}) in lipstick samples

Lipstick Brands	**Parameter**	**Lead (Pb) (mg.kg^{-1})**	**Cadmium (Cd) (mg.kg^{-1})**	**Chromium (Cr) (mg.kg^{-1})**
A	Mean ± SD	3.423 ± 1.519	0.012 ± 0.001	2.171 ± 0.961
	Min-Max	1.962 – 5.334	0.010 – 0.013	1.045 – 3.161
B	Mean ± SD	1.579 ± 0.672	0.067 ± 0.060	1.299 ± 1.192
	Min-Max	0.787 – 2.430	0.013 – 0.122	0.299 – 2.974
C	Mean ± SD	0.859 ± 0.547	0.044 ± 0.051	0.677 ± 0.196
	Min-Max	0.054 – 1.275	0.017 – 0.120	0.237 – 1.155
D	Mean ± SD	4.137 ± 1.819	0.079 ± 0.094	2.126 ± 0.988
	Min-Max	2.143 - 6.557	0.002 – 0.196	1.043 – 3.352
E	Mean ± SD	1.342 ± 0.480	0.019 ± 0.013	1.106 ± 0.620
	Min-Max	0.662 – 1.787	0.004 – 0.030	0.304 – 1.742
F	Mean ± SD	2.006 ± 0.929	0.008 ± 0.007	1.031 ± 0.661
	Min-Max	0.771 – 2.834	0.001 – 0.015	0.547 – 1.705
G	Mean ± SD	2.631 ± 0.760	0.021 ± 0.005	1.081 ± 0.762
	Min-Max	1.928 – 3.508	0.018 – 0.028	0.055 – 1.704
H	Mean ± SD	1.515 ± 0.636	0.005 ± 0.003	1.174 ± 0.743
	Min-Max	1.085 – 2.461	0.002 – 0.009	0.380 – 1.867
I	Mean ± SD	1.498 ± 1.018	0.013 ± 0.005	2.344 ± 1.293
	Min-Max	0.489 – 2.662	0.005 – 0.017	1.047 – 3.731
J	Mean ± SD	3.256 ± 1.369	0.025 ± 0.012	1.163 ± 0.428
	Min-Max	1.630 – 4.834	0.015 – 0.038	0.704 – 1.704
K	Mean ± SD	1.615 ± 1.248	0.014 ± 0.009	0.939 ± 0.387
	Min-Max	0.054 – 3.047	0.005 – 0.023	0.454 – 1.380
L	Mean ± SD	2.419 ± 0.779	0.039 ± 0.051	1.895 ± 0.895
	Min-Max	1.589 – 3.273	0.010 – 0.115	1.048 – 3.063
Total	Mean ± SD	2.120 ± 1.336	0.028 ± 0.041	1.417 ± 0.785
	Min-Max	0.054 – 6.557	0.001 – 0.196	0.667 – 2.344
WHO^{MAC}		10	0.3	NA
EU^{MAC}		0.5	0.5	1
Health Canada^{MAC}		10	3.0	NA

Note: MAC = Maximum Allowable Concentration; NA = Not Applicable.

Table 4: Results of a one-way ANOVA for comparing the concentrations of heavy metals in different lipstick brands (dependent variables were transformed)

Element		**Sum of Squares**	**df**	**Mean Square**	**F**	***p*-value**
Pb	Between Groups	43.426	11	3.948		
	Within Groups	40.521	36	1.126	3.507	0.002
	Total	83.947	47			
Cd	Between Groups	0.025	11	0.002	1.521	0.167
	Within Groups	0.054	36	0.001		

	Element	Sum of Squares	df	Mean Square	F	*p*-value
	Total	0.079	47			
Cr	Between Groups	106.895	11	9.718		
	Within Groups	141.045	36	3.918	2.480	0.020
	Total	247.940	47			

Table 5: Average Daily Dose (ADD_{ing}) and health risk assessments (HQ and HI) of heavy metals in lipstick samples

Lipstick Brands	Average Daily Dose (ADD_{ing}) ($mg.kg^{-1}.day^{-1}$)			Hazard Quotient (HQ)			Hazard Index (HI)
	Pb	Cd	Cr	Pb	Cd	Cr	
A	1.626E-03	0.569E-05	1.031E-03	0.407	0.006	0.344	0.757
B	0.749E-03	3.182E-05	0.617E-03	0.187	0.032	0.206	0.419
C	0.408E-03	2.089E-05	0.321E-03	0.102	0.021	0.107	0.230
D	1.965E-03	3.752E-05	1.009E-03	0.491	0.038	0.336	0.865
E	0.637E-03	0.902E-05	0.525E-03	0.159	0.009	0.175	0.343
F	0.953E-03	0.379E-05	0.489E-03	0.234	0.004	0.163	0.401
G	1.249E-03	0.997E-05	0.513E-03	0.312	0.010	0.171	0.493
H	0.719E-03	0.237E-05	0.558E-03	0.179	0.002	0.186	0.367
I	0.711E-03	0.617E-05	1.113E-03	0.178	0.006	0.371	0.555
J	1.546E-03	1.187E-05	0.552E-03	0.391	0.012	0.184	0.587
K	0.767E-03	0.665E-05	0.446E-03	0.192	0.007	0.149	0.384
L	1.149E-03	1.852E-05	0.899E-03	0.287	0.019	0.299	0.535
Total	1.039E-03	1.369E-05	0.673E-03	0.259	0.014	0.224	0.495

Table 6: Estimated daily intake (EDI) and relative intake index (RII) of heavy metals in lipstick samples

Lipstick Samples	Pb		Cd		Cr	
	EDI ($\mu g.g^{-1}$)	RII (%)	EDI ($\mu g.g^{-1}$)	RII (%)	EDI ($\mu g.g^{-1}$)	RII (%)
A	0.137	2.740	0.000	0.009	0.087	0.812
B	0.063	1.263	0.003	0.054	0.052	0.486
C	0.034	0.687	0.002	0.035	0.027	0.253
D	0.165	3.309	0.003	0.063	0.085	0.795
E	0.054	1.074	0.000	0.015	0.044	0.413
F	0.080	1.605	0.000	0.006	0.041	0.385
G	0.105	2.105	0.000	0.017	0.043	0.404
H	0.061	1.212	0.000	0.004	0.047	0.439
I	0.059	1.198	0.000	0.010	0.094	0.876
J	0.130	2.605	0.001	0.020	0.047	0.435
K	0.065	1.292	0.000	0.011	0.038	0.351
L	0.097	1.935	0.002	0.031	0.076	0.708
Total	0.087	1.752	0.000	0.023	0.057	0.530

Discussion

Heavy metals are hazardous to human health and using different types of cosmetics products, such as lipstick, is away human beings are exposed to heavy metals. The present study aimed to investigate heavy metal (Pb, Cd, and Cr) concentrations in different lipstick brands commonly found in Bangladesh and to assess associated health risks to lipstick consumers. Many customers make regular use of such goods and, therefore, subject themselves to the danger of these metals. While in many developing countries the usage of metals as additives in cosmetics is forbidden, metallic impurities cannot be eliminated except in good industrial technique, since they occur naturally in the environment. To the best of the author's knowledge, this is the first study of its kind in Bangladesh, concentrating solely on the effects of heavy metals on lipstick. Heavy metal levels (lead, cadmium, and chromium) in twelve lipstick brands were examined in this study.

Concentration of heavy metals in lipstick samples

Lead (Pb), a highly toxic heavy metal is absorbed in inorganic forms through ingestion by food and water, and inhalation. The average Pb concentration in the brands analysed ranged from 0.054 to 6.557 $mg.kg^{-1}$ (ww), with a mean of 2.120 mg kg^{-1} (ww), which is lower than the previous Bangladeshi cosmetics studies–(Alam et al., 2019). Previous studies also focused on the concentration of lead content in lipstick samples (Malvandi and Sancholi, 2018; Piccinini et al., 2013; Zainy, 2017; Zakaria and Ho, 2015). The concentration of lead in this study was comparable with the study conducted in Iran which found the concentration of Pb was 0.290 to 6.780 $mg.kg^{-1}$ (ww) with a mean of 1.851 $mg.kg^{-1}$ (ww) in the brands considered (Malvandi & Sancholi, 2018). A higher concentration of lead found in lipsticks in Malaysia ranged from 0.77 to 15.44 $mg.kg^{-1}$ (ww) (Zakaria & Ho, 2015), Saudi Arabia (3.15 to 8.22 $mg.kg^{-1}$ (ww)) (Zainy, 2017), and India (0.10 to 25.80 mg kg^{-1} (ww)) (Belurkar & Yadawe, 2017). A study carried out in South Korea, found Pb concentration in lipsticks, which ranged from not detected (ND) to 9.28 (Lim, et al., 2018); in Jordan 0.43 to 2.34 $mg.kg^{-1}$ (Ababneh & Al-Momani, 2018); and it ranged from ND to 4.89 $mg.kg^{-1}$ in Brazil and Portugal (Pinto et al., 2018). This significant variation in lead concentration can be due to the consistency of the raw materials used in lipstick manufacturing. Despite the fact that the amount of Pb absorbed by the skin is less than 1%, several organizations have set limits on the amount of Pb in cosmetics (Moazenzadeh et al., 2011). The safe permissible limit for lead in cosmetics, as suggested by Health Canada and US Food and Drug Administration, are 10 ppm and 20 ppm, respectively (Health Canada, 2012). All of the lipsticks in this sample had Pb values that were lower than the recommended levels. Cosmetic products with high levels of Pb, either administered once or many times a day, may result in human sensitivity to Pb (Bellinger, 2008). A few of the components in lipsticks may penetrate the skin through the circulatory system and enter essential internal organs. Furthermore, lipsticks often have a greater chance of overt oral intake and may worsen the adverse effects of their chemicals (Wang et al., 2008).

Cadmium (Cd) is refined and consumed for use in cosmetics products owing to its property as a colored pigment (Godt et al., 2006). The mean content of Cd for lipstick determined in this study (0.001 to 0.196 $mg.kg^{-1}$ (ww)) was comparable with a similar study that found Cd concentration on lipstick ranged 0.002 to 0.107 $mg.kg^{-1}$ (Malvandi & Sancholi, 2018). A previous study found cadmium concentrations in cosmetics products in Bangladesh was varied from 2.40 to 6.27 $mg.kg^{-1}$ (Alam et al., 2019). Cd ranges from 0.12 to 2.72 and 0.34 to 37.3 $mg.kg^{-1}$ in lipstick in Jordan and Nigeria, respectively (Ababneh & Al-Momani, 2018; Iwegbue et al., 2016) and also in Brazil, Malaysia, Portugal, and South Korea range from ND to 1.97 $mg.kg^{-1}$ (Lim et al., 2018; Pinto et al., 2018; Zakaria & Ho, 2015). The Cd values reported in the literature are lower than the Health Canada and WHO safe permissible limits of 3 mg.kg-1 and 0.3, respectively (Alam et al. 2019; Health Canada, 2012). Gondal et al. (2010) reported the concentrations in the range from 4.9 to 10.6 $\mu g.g^{-1}$. The New Zealand Centre for Public Health Research detected concentrations of Cd from 1.1 to 3390 $\mu g.g^{-1}$ (CPHR, 2011).

Chromium (Cr) concentrations in lipstick have been found in different ranges based on different studies. The range of the content of Cr in this study (0.667 to 2.344 $mg.kg^{-1}$ ww) was comparable with Cr concentrations (ND-2.82 $\mu g.g^{-1}$) found in Bangladeshi cosmetics (Alam et al., 2019). But lower than facial makeup cosmetics (eyeliner, eye pencil, and lipstick) in the Nigerian market, with Cr levels in the range of 20.5–64.3 $\mu g.g^{-1}$ (Nnorom et al., 2005). A study conducted in New Zealand with 201 lipstick products, the concentration of Cr was between ND and 5 $\mu g.g^{-1}$; among them, 141 samples exceeded 5 $\mu g.g^{-1}$ and the highest concentration was 230 $\mu g.g^{-1}$ (CPHR, 2011). The concentration of Cr in lipstick ranges from 2.26 to 2.80 $mg.kg^{-1}$ in Brazil and Portugal (Pinto et al., 2018). The mean Cr values obtained in this study were similar to those of Brazil and Portugal. But in contrast, a higher Cr concentration was found in Nigeria (17.1 to 116 $mg.kg^{-1}$) (Iwegbue et al., 2016). According to the EU, the permissible limit for chromium is 1.0 $\mu g.g^{-1}$(Alam et al., 2019). In that way, the mean concentration of chromium found in this study exceeded the standard value. Cr levels in consumables should not exceed 5 $mg.kg^{-1}$, and even less than 1.0 $mg.kg^{-1}$ is advised for optimal health, according to certain research (Basketter et al., 2003). Other studies, on the other hand, recommend that Cr concentrations should not exceed 170 $mg.kg^{-1}$ (Malvandi & Sancholi, 2018; Zainy, 2017). The Cr levels in this study were lower than those proposed by Zainy (2017) and Mansouri et al. (2017), but higher than those reported by Basketter et al. (2003) (5 $mg.kg^{-1}$). It should be mentioned that high quantities of this element are known to cause skin allergies.

The difference in lead, cadmium, and chromium content between different lipstick brands was determined using the ANOVA. This study found that there was a significant difference in lead and chromium content among the lipsticks in different brands ($p < 0.05$) found in the Bangladeshi market, but no significant difference has found in terms of cadmium, which is comparable with a previous study that showed a significant difference between the concentrations of lead, cadmium, and chromium in different lipstick brands ($p < 0.05$) in Iran (Malvandi & Sancholi, 2018). A previous study found that there was a significant difference in lead content ($p < 0.05$). Studies conducted in Italy and Malaysia showed that piece has a significant effect on containing lead in lipstick brands, expensive lipsticks contained a significantly lower quantity of lead in comparison to cheap lipsticks (Piccinini et al., 2013; Zainy, 2017).

Health risk assessment

In contrast to water, food, and air, heavy metals in cosmetics may appear to be a minor source of health hazards. Cosmetics, on the other hand, should not be overlooked because they are worn for long periods of time and are frequently applied to thin and sensitive parts of the skin, such as the lips and eye contours. Limited awareness of the concentrations of heavy metals in these products and their potential health hazards among consumers of cosmetics is a key concern for the use of cosmetic products. Possible carcinogens have been identified as lead, cadmium, and chromium. The assessment of the carcinogenic health risk of heavy metals in lipsticks, however, has certain limitations because the cancer slope factor for ingestion was not accessible in the risk assessment databases. To determine the risk of Pb, Cd, and Cr in lipstick samples, the HQ, HI, EDI, and RII indices were used (Tables 5 and 6). The HI index values were in the 0.230 to 0.865 range and the HQ index values were in the 0.002 to 0.407 range. There is no risk to consumers' well-being if the values obtained from the HQ and HI indices are less than 1. All of the elements assessed in this study (Pb, Cd, and Cr) had HQ values lower than the reference value 1. Besides, all twelve lipstick brands had HI index values of less than one (Table 5). Overall, the findings of the HQ and HI indices suggest that there is no possible health risk to customers for all brands of lipstick because of the inclusion of these components in the lipstick. The EDI and RII indices were also used to determine the health risk (Table 6). The values of RII for Pb, seven, out of twelve, brands were more than 1.50, greater than the limits enforced by the European Medicines Agency for drug products. In terms of Cd, five out of twelve lipsticks had RII values higher than the reference value of 0.02, while in terms of Cr, all lipstick brands had RII values larger than 0.002, which was higher than the reference value (EMA, 2019).

Besides, the lipstick sampling was focused on the popularity of the study area's respondents. If attention to lipstick products is applied to the entire industry, the safety impact can potentially be important. To the best of the author's knowledge, the chronic health risk of wearing heavy metal-contaminated lipstick was measured for the first time. The results of the study are particularly important in light of the lack of knowledge on the presence of heavy metals in lipsticks sold in Bangladesh and the need to protect the health of lipstick users.

Conclusions

The quantities of these heavy metals in cosmetics were generally below the safe allowed range. The amount of lead and chromium in various brands of lipstick differed greatly. The indices used to measure the health risks of these components (HQ and HI) for all metals in all lipsticks were, however, lower than 1. This suggests that exposure to these heavy metals through the ingestion of lipsticks posed no significant chronic non-carcinogenic health risk. In general, due to the accumulative qualities of these elements and the expanding use of cosmetics, as well as excessive use of cosmetics should be approached with caution. Continuous surveillance and quality control of these lipstick products are urgently needed to rescue consumers from the potential health risks associated with the use of lipsticks. In the manufacturing of cosmetic products, regulatory guidelines on heavy metals in cosmetics should be formulated and implemented by authorities. The adverse consequences of prolonged or intensive use of cosmetic products should be made known to the general public. Heavy metal content of cosmetics and other household goods and items should be limited by legislation.

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