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Levels and Exposure Risks of Lead, Arsenic and Mercury from Selected Lipstick and Nail Polish Cosmetics Marketed in Dar es Salaam, Tanzania

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Abstract

Presence of Pb, As and Hg in selected lipstick and nail polish cosmetics sold at different shopping malls and retail outlets in Dar es Salaam was determined by microwave plasma atomic emission spectrometry due to their public health effects. Pb was detected in 100% (n = 25) of lipsticks and 53.3% (n = 15) of nail polishes. Arsenic was detected in 36% of lipsticks and 86.7% of nail polishes, and Hg was detected in 44% of lipsticks and 80% of nail polishes. All metal levels in both cosmetics were below the World Health Organisation (WHO) and Tanzania Bureau of Standards (TBS) maximum recommended limits. Health-based risks were evaluated using chronic daily intake (CDI), non-carcinogenic hazard quotient (HQ), hazard index (HI) as well as carcinogenic total risk. CDI values in all cosmetics were lower than maximum tolerable daily intake (MTDI). HQs of all metals in most of the lipsticks and all nail polishes were < 1, indicating little health risks. Both HI and carcinogenic risk were lower, indicating that they are relatively safe and have little potential carcinogenic risk. Determined potential carcinogenic risks were lower, indicating little carcinogenic risk. Awareness of potential effects and continuous monitoring are recommended to raise awareness of consumers and control quality of cosmetics as metals are cumulative toxicants.

Keywords: Heavy metal, lipstick, nail polish, Tanzania, cosmetics.

Introduction

Cosmetics are used daily and are applied on the thinnest parts of the body such as lips and nails (Corazza et al. 2009). Heavy metals such as Pb, As and Hg are the common constituents as either impurities or ingredients (Alam et al. 2019). Since metals in the cosmetic products are usually water soluble, their absorption is likely to be very high (Corazza et al. 2009). Both lipsticks and nail polishes are used worldwide and their uses are increasing day after day. On the other hand, continuous use as well as the use of cosmetics in combination may be associated with continuous exposure and health risks particularly in less developed countries (Järup 2003). For example, metals in lipsticks can be easily swallowed accidentally during eating, and metals in nail polish can reach the body via porous keratinised nails (Ouremi and Ayodele 2014). As a result, avoiding exposure to heavy metals through the skin, food, air or water is difficult (Ouremi and Ayodele 2014).

Heavy metals are known to accumulate (Alam et al. 2019) and are known to be toxic when there is excessively high intake (Çelik and Oehlenschläger 2007). The nature of effects could be chronic toxicity. Examples of chronic toxic effects include neurotoxic, carcinogenic, mutagenic or teratogenic effects (Linnik 2000, Radwan and Salama 2006, Duruibe et al. 2007). Heavy metals toxicity can result to damaged or reduced mental and central nervous functions, lower energy levels and damage to blood composition, lungs, liver, kidneys and other vital organs (Linnik 2000). Lead (Pb), for example, is a common contaminant in various cosmetic products (Chauhan et al. 2010, Ahmed et al. 2016, Alam et al. 2019). Pb toxicity may lead to anaemia, neuropathy, nephropathy, sterility, coma, behavioural abnormalities, learning impairment, decreased hearing and impaired cognitive functions (Nnorom et al. 2005). In addition Pb can cause low birth weight, premature delivery as well as intrauterine death (Al-Saleh et al. 2009). Arsenic (As) is used in various products including textiles, preservative and pigments (Agency for Toxic Substances and Disease Registry, ATSDR 2007). Long-term exposure effects of arsenic may lead to skin effects, circulatory and peripheral nervous disorders as well as increased lung, gastrointestinal tract and urinary system cancer risks (ATSDR 2007, Omolaoye et al. 2010, Ahmed et al. 2016). Mercury (Hg) is a common ingredient in skin lightening soaps, nail polishes and creams (Sin and Tsang 2003). Absorption of Hg through the skin may result to renal neurological and dermal toxicity, headache, insomnia, memory loss, irritability, abdominal discomfort, nervousness, joint pain, weakness, nausea as well as hand tremor (Sin and Tsang 2003). Despite these health risks, the available regulations on cosmetics have set no exact limit of the heavy metal contents in cosmetics (Sainio et al. 2000), neither there are no universal legislation governing presence of heavy metals in cosmetics (Borowska and Brzóska 2015).

Various studies have been conducted to evaluate the levels and/ or exposure of heavy metals in lipstick and nail polish cosmetics. Among the heavy metals Pb, As and Hg are of concern to public health due to the cumulative toxic effects and risks on exposure. Studies conducted in the Middle East and West African countries have revealed presence of these metals in different lipstick and nail polish cosmetics. For example, a study by Adepoju-Bello et al. (2012) revealed that Pb was detected in all lipsticks sold in Nigeria at concentration range of 0.017–0.09 ppm. Similarly, Al-Qutob et al. (2013) observed that lipsticks sold in Palestina contained Pb up to 15.92 ± 1.61 ppm. Furthermore, lipsticks sold in Saudi Arabia were observed to contain Pb of up to 0.039 ppm (Al-Qahtani et al. 2016). Higher levels of Pb of up to 18.21 ± 0.08 ppm were observed in lipsticks sold in Kaduna, Nigeria (Nasirudeen and Amaechi et al. 2015). Rahil et al. (2019) also observed that lipsticks sold in Libya contained Pb up to 7.95 ± 2.76 ppm. Similarly, Adepoju-Bello et al. (2012) observed the presence of As and Hg contents in lipsticks sold in Nigeria. Levels of As and Hg were at concentration ranges of 0.006–0.031 and 0.009–0.207 ppm, respectively. In addition, Al-Qahtani et al. (2016) observed that As in the selected lipsticks sold in Saudi Arabia ranged from 0.00093 to 0.15398. ppm, while Hg ranged from ND to 1.52 ppm. Al-Qahtani et al. (2016) also observed that the levels were varying depending on the costs of the cosmetics. The levels of Pb and As in nail polishes were also detected by Karimi and Ziarati (2015) in nail polishes sold in Iran. The Pb levels in these cosmetics were observed to range from 1.0 to 33.8 ppm, while As ranged from 0.23 to 5.89 ppm. Levels of Pb up to 42.14 ppm have been detected in nail polishes sold in Nigeria (Ouremi and Ayodele (2014).

There is an increasing trade of lipsticks and nail polish cosmetics in Tanzania that are imported from different countries and from various manufacturers. The qualities of the different cosmetics are not known with certainty. This is because the availability of heavy metals in almost every cosmetic product as impurities is inevitable (Rahil et al. 2019). In addition, their identity as well as the amount in a given cosmetic product are not indicated during the manufacturing and labelling. This increases the risks of consumers' exposure to heavy metals in a cumulative basis. The availability of many new cosmetic products on the market further compounds the problem and makes necessary to have continuous monitoring on a regular basis.

There is no documented study on the quality of lipsticks and nail polishes sold in retail shops in Tanzania at large and Dar es Salaam in particular. Furthermore, the levels of heavy metals in the cosmetic products sold in Tanzania are not known in comparison with the WHO and TBS maximum set standards. Moreover, the exposure risks of the heavy metals in cosmetics sold in Tanzania are not understood. Therefore, this study was intended to assess the quality of selected lipsticks and nail polishes sold at different shopping malls and retail outlets in Dare es Salaam by determining the levels of Pb, As and Hg and comparing them with the WHO and TBS maximum set standards. Furthermore, chronic, non-carcinogenic and carcinogenic exposure risks associated with the lipsticks and nail polishes were assessed.

Materials and Methods

Chemicals, reagents and solvents

All chemicals, reagents and solvents used were of analytical grade. Stock standards of lead, arsenic and mercury were obtained from Agilent Technologies, USA. Hydrochloric acid, concentrated nitric acid, hydrogen peroxide and sulphuric acid were sourced from Sigma Aldrich, UK. L-cysteine and tartaric acid were purchased from Fisher Scientific, UK.

Sampling

Purposive sampling was employed to obtain lipstick and nail polish samples from different shopping malls and retail outlets in Dar es Salaam in March, 2019. A total of forty (40) samples were obtained, which included twenty five (25) samples of lipsticks and fifteen (15) of nail polishes. To keep the brand names anonymous, all lipstick samples were coded LS (LS01–LS25) and nail polish samples were coded NP (NP01–NP15). The samples were stored at room temparature before processsing in the laboratory.

Sample preparation

Prior to sample preparation, all containers and glassware were thoroughly cleaned with liquid detergent, warm water and rinsed with distilled water. Then, they were soaked in 10% HNO_3 (analytical grade) overnight before rinsing with distilled water. All the lipstick and nail polish samples were prepared in triplicate according to a method described by Kratochvil (2003). Each lipstick and nail polish (0.50 g) was measured in a Teflon container. Then concentrated nitric acid (4 mL) and 30% hydrogen peroxide (1 mL) were added and the container closed. After 15 min of reaction, the mixture was microwave digested at the temperature between 180 °C and 200 °C for 3 hours. The resulting solution was then cooled before addition of distilled water (20 mL) and filtration into a volumetric flask (50 mL) using Whatman filter paper (No. 1). Prior to analysis, the filtrate was diluted to the mark with distilled water, 3% HCl and 2% L-cysteine in 4% tartaric acid for Pb, Hg and As samples, respectively.

Preparation of working standard solutions

Working standards solutions were freshly prepared from stock standard solutions by serial dilutions. To prepare the working solutions, 10,000 ppm, 10,000 ppm and 50 ppm of Hg, As and Pb stock standard solutions, respectively were used. Five working standard solutions of each metal were prepared in the concentration ranges of 10–50 ppm for Pb, 2.0–10.0 ppm for As and 0.5–5.0 ppm for Hg. The working standards were used to generate the respective calibration curves.

Measurements of levels of Pb, Hg and As

Analysis of the metals in the selected cosmetics was done using Agilent 4210 Microwave Plasma-Atomic Emission Spectrometer (MP-AES), Santa Clara, USA. MP-AES is selective, highly specific analytical instrument, which can analyze all the selected heavy metals at good precision. Nitrogen was set to flow at 4.5 L/min for all metals. The instrument was set to operate in the conditions displayed in Table 1.

Table 1: MP-AES operating conditions

Metal	Wavelength (nm)	Nebulizer flow (L/min)	Fast pump (rpm)	Pump speed (rpm)	Stabilization time (s)	Detection limit (ppb)
Pb	368.346	0.60	80	12	5	1.6
As	234.984	0.50	80	10	5	5.7
Hg	253.652	0.45	80	10	10	4.5

Quantification of the metals was achieved through the use of external standards. Stock standards of Pb, As and Hg were used to prepare the working standards. Six serial standards with concentrations 0.01, 0.05, 0.1, 0.4, 1.0 and 2.0 ppm were prepared for each metal and were used to produce the calibration curves. The resulting regression lines were employed in quantifying the respective metals in the cosmetic brands. All calibration curves gave regressions that had $r^2 > 0.96$.

Health risk assessments

In order to assess the human risks due to metals in the analysed cosmetics, the United States Environmental Protecion Agency (USEPA 2015) model was used. In this model, the risks can either be chronic, non-carcinogenic or carcinogenic. Chronic exposure to metals due to prolonged use of cosmetics can be through ingestion, inhalation (mouth and nose) or dermal absorption. For lipstick and nail polish cosmetics, ingestion through the mouth and dermal absorption are significant for Pb and As whereas in Hg all three are important routes.

The chronic daily intake (CDI) was calculated using the Equations 1-3 (De Miguel et al. 2007):

Ingestion intake (IngI) per day (mg/kg) =

$$\frac{C \times CF \times EF \times ED \times FI \times IR}{AT \times BW} \qquad \text{Equation 1}$$

Dermal intake (DI) per day (mg/kg) =

$$\frac{C \times CF \times AF \times EF \times ED \times ABS \times SA}{AT \times BW} \qquad \text{Equation 2}$$

Inhalation intake (InhI) per day (mg/kg) =

$$\frac{C \times RI \times EF \times ED}{AT \times BW \times VF} \qquad \text{Equation 3}$$

Summation of ingestion, dermal and inhalation intakes gave the total CDI of a given cosmetic brand. The abbreviations and values used in the determination of CDI are given in Table 2.

Non-carcinogenic risk (hazard quotient, HQ) of the metals was determined as the ratio of exposure to hazardous substance (i.e. CDI) to chronic reference of the metal or reference dose, RFD:

$$HQ = \frac{CDI}{RFD}$$

The RFD used were adopted from De Miguel et al. (2019) and are given in Table 3.

Table 2: Exposure values used in determination of CDI (USEPA 2001, 2002, 2015, Alam et al. 2019)

Exposure factor	Description	Value
C	Concentration of the metal in cosmetic in mg/kg	-
CF	Conversion factor (in kg/mg)	x 10^{-6}
ED	Duration of exposure (in years)	30
EF	Frequency of exposure (in events or days /year),	350
FI	Fraction of concentration ingested	0.05
IR	Rate of ingestion (in mg/day)	100
AF	Adherence factor, cosmetic to skin adherence (in mg/cm^2)	0.07
ABS	Absorption factor	0.001
SA	Surface area of contact (in cm^2/event)	400
RI	Rate of inhalation of vapour (in m^3/day)	14.4
VF	Volatilisation factor of Hg (in m^3/kg) 2001)	32,376.4
AT	Averaged time, period of time over which exposure is averaged (in days),	25,550
BW	Body weight (in kg)	70

Table 3: Chronic reference doses or RFD of the analysed metals

Metal	Reference dose ($mgkg^{-1}day^{-1}$ $x10^{-4}$)		
	Ingestion	Dermal	Inhalation
Pb	35.0	5.25	-
As	3.0	1.23	-
Hg	3.0	0.21	0.857

The non-carcinogenic hazard index (HI) for all the metals was determined by summing up all the HQ of each analysed metal in the cosmetic, such that :

$$HI = \sum HQ = HQ_{Pb} + HQ_{As} + HQ_{Hg}$$

Carcinogenic risk was determined by multiplying the CDI with the slope factor (SF) or RFD of hazardous substance (Table 3). The detection limits used in the calculations were those determined earlier (Table 1).

Quality assurance and control

The quality assurance and quality control, QA/QC, procedures were followed throughout the analytical steps. Blanks and recovery tests were determined to check for the accuracy of the method and reliability of the results obtained. Procedural blank samples were included in every batch and were subjected to similar treatments like normal samples. Blank correction of the samples was done where the blank samples used contained some levels of the metals. The mean percentage recoveries of Pb, As and Hg (n = 3) were 98.0%, 97.7% and 98.6%, respectively, which is within the acceptable recovery range and an indication that the results are within acceptable accuracy (Taylor et al. 2006). Calibration curves of intensities against respective concentrations were plotted and correlation coefficients determined to express the instrumental performance. The calibration curves of all metals gave linear relationships with r^2 equal to 0.9995 for Pb, 0.9977 for As and 0.9983 for Hg.

Data analysis

Mean and standard deviation (STD) of the replicate samples of heavy metals in lipstick and nail polish cosmetics were determined using IBM SPSS (v. 23). The normality of the data was determined using SigmaPlot (v. 11). All data were not normally distributed. The Independent Kruskal-Wallis One Way Analysis of Variance (ANOVA) on ranks was then performed to determine the differences in the medians between different metals in the analysed brands at $p < 0.05$ and 95% confidence level.

Results and Discussion

Mean levels of heavy metals in lipstick cosmetics

The levels of Pb were observed in all (100%, n = 25) lipstick cosmetics analysed and the mean levels ranged from 0.02 ± 0.01 μg/g to 1.00 ± 0.11 μg/g (Table 4). The mean concentrations of Pb in different lipstick brands were significantly different ($t = 5.047$, $df = 24$, $p < 0.001$). Arsenic was detected in 9 (36%) lipstick brands and the concentrations in lipsticks ranged from 0.01 ± 0.01 μg/g to 0.03 ± 0.01 μg/g. The levels of As in different brands were significantly different ($t = 6.815$, $df = 24$, $p < 0.001$). Mercury was detected in 11 (44%) lipstick brands, the concentrations in the lipsticks ranged from 0.01 ± 0.01 μg/g to 0.24 ± 0.05 μg/g (Table 4). The concentrations of Hg in different lipstick brands were significantly different ($t = 2.512$, $df = 24$, $p < 0.019$). The levels of Pb, As, and Hg in lipstick cosmetics were lower than the TBS and WHO maximum recommended limits (TBS 2014, WHO 1995).

Table 4: Mean levels (μg/g ± SD, n = 3) of heavy metals in lipsticks

Brand	Sample code	Pb	As	Hg
1	LS01	0.11 ± 0.02	BLD	BLD
2	LS02	0.13 ± 0.04	0.02 ± 0.01	0.05 ± 0.02
3	LS03	0.14 ± 0.01	BLD	BLD
4	LS04	0.18 ± 0.03	0.01 ± 0.01	0.07 ± 0.02
5	LS05	0.16 ± 0.01	BLD	BLD
6	LS06	0.07 ± 0.01	BLD	BLD
7	LS07	0.24 ± 0.04	BLD	BLD
8	LS08	0.15 ± 0.01	BLD	BLD
9	LS09	0.13 ± 0.03	0.02 ± 0.01	BLD
10	LS10	0.13 ± 0.01	BLD	0.01 ± 0.01
11	LS11	1.00 ± 0.36	0.01 ± 0.01	0.01 ± 0.01
12	LS12	0.13 ± 0.02	BLD	BLD
13	LS13	0.02 ± 0.01	BLD	0.01 ± 0.01
14	LS14	0.11 ± 0.01	0.02 ± 0.01	0.01 ± 0.01
15	LS15	0.11 ± 0.01	BLD	BLD
16	LS16	0.22 ± 0.01	BLD	0.24 ± 0.05
17	LS17	0.09 ± 0.02	0.03 ± 0.01	0.02 ± 0.01
18	LS18	0.23 ± 0.02	0.01 ± 0.01	BLD
19	LS19	0.13 ± 0.01	BLD	0.08 ± 0.03
20	LS20	0.19 ± 0.01	BLD	0.03 ± 0.02
21	LS21	0.50 ± 0.04	0.03 ± 0.01	BLD
22	LS22	0.26 ± 0.01	BLD	BLD
23	LS23	0.40 ± 0.04	BLD	0.02 ± 0.01
24	LS24	0.11 ± 0.01	0.01 ± 0.01	BLD
25	LS25	0.37 ± 0.01	BLD	BLD
	WHO	10	10	1
	TBS	20	2	2

BLD = Below Limit of Detection: 0.002 ppm for Pb, 0.006 ppm for As and 0.005 ppm for Hg.

Mean levels of heavy metals in nail polish cosmetics

The levels of Pb in nail polishes were observed in 8 (53.3%) analysed brands, with the mean levels ranging from BLD to 0.09 ± 0.01 μg/g (Table 5). Seven brands of nail polishes had Pb levels below the detection limit. The mean levels of Pb in different nail polish brands were significantly different ($t = 2.479$, $df = 14$, $p < 0.027$). Arsenic was detected in 13 (86.7%) nail polish brands in which the concentrations ranged from 0.01 ± 0.01 µg/g to 0.32 ± 0.04 µg/g (Table 5). Two brands of nail polishes had As levels below the detection limit. The concentrations of As in different nail polish brands were significantly different ($t = 3.194$, $df = 14$, $p < 0.006$). Mercury was detected in 12 nail polishes brands (80%), with the concentrations ranging from 0.03 ± 0.01 to 0.73 ± 0.03 µg/g (Table 5). Only 3 brands of nail polishes had Hg levels below the detection limit. The concentrations of Hg in different nail polish brands were significantly different ($t = 2.929$, $df = 14$, $p < 0.011$). The levels of Pb, As and Hg in nail polish cosmetics were lower than the maximum recommended limits set by TBS and WHO set satandards (TBS 2014, WHO 1995).

Table 5: Mean levels (µg/g ± SD, n = 3) of heavy metals in nail polishes

Brand	Sample code	Pb	As	Hg
A	NP01	0.01 ± 0.01	0.06 ± 0.02	0.14 ± 0.02
B	NP02	BLD	0.02 ± 0.01	BLD
C	NP03	0.01 ± 0.01	BLD	0.16 ± 0.02
D	NP04	0.02 ± 0.01	BLD	0.16 ± 0.01
E	NP05	BLD	0.11 ± 0.02	0.07 ± 0.01
F	NP06	0.09 ± 0.01	0.32 ± 0.04	0.04 ± 0.01
G	NP07	0.01 ± 0.01	0.01 ± 0.01	0.73 ± 0.03
H	NP08	0.01 ± 0.01	0.21 ± 0.05	0.03 ± 0.01
I	NP09	0.01 ± 0.01	0.19 ± 0.03	BLD
J	NP10	BLD	0.03 ± 0.01	0.33 ± 0.03
K	NP11	0.02 ± 0.01	0.08 ± 0.01	0.05 ± 0.01
L	NP12	BLD	0.02 ± 0.01	0.40 ± 0.07
M	NP13	BLD	0.05 ± 0.02	0.09 ± 0.02
N	NP14	BLD	0.02 ± 0.01	0.04 ± 0.01
O	NP15	BLD	0.02 ± 0.01	BLD
	WHO	10.0	3.0	1.0
	TBS	20.0	2.0	2.0

BLD = Below Limit of Detection: 0.002 ppm for Pb, 0.006 ppm for As and 0.005 ppm for Hg

Comparison of metals in lipsticks and nail polishes sold in other African and Asian countries

The observed mean levels of Pb in lipsticks were within the ranges of values observed by Al-Qutob et al. (2013), higher than the levels of Pb observed by Adepoju-Bello et al. (2012) and Al-Qahtani et al. (2016), but lower than those observed by Ahmed et al. (2016), Nasirudeen and Amaechi et al. (2015) and Philip et al. (2018). Mean levels of As were within the range of values observed by Adepoju-Bello et al. (2012), Al-Qahtani et al. (2016) and Philip et al. (2018), but higher than the values observed by Ahmed et al. (2016) and lower than those observed by Nasirudeen and Amaechi et al. (2015). The mean levels of Hg observed in lipsticks were within the range of values observed by Adepoju-Bello et al. (2012), Nasirudeen and Amaechi et al. (2015) and Philip et al. (2018). However, the observed levels of Hg were comparable to those observed by Al-Qahtani et al. (2016) but lower than the values observed by Al-Qahtani et al. (2016) in some samples (Table 6). The observed variations of the levels of metals in the analysed lipstick cosmetics indicate that the products sold in Tanzana have different compositions compared to those sold elsewhere. In the nail polish cosmetics, the observed mean levels of Pb were lower than the levels of Pb observed by Ouremi and Ayodele (2014), Ackah et al. (2015), Karimi and Ziarati (2015) and Mahugija (2018). Mean levels of As observed were lower than the levels of As observed by Ouremi and Ayodele (2014) and Karimi and Ziarati (2015). There was no current study that observed the levels of Hg in nail polishes.

Table 6: Ranges of Pb, As and Hg in lipstick and nail polish cosmetics sold in other countries

Type of cosmetic	Mean or range (ppm)			Reference
	Pb	As	Hg	
Lipstick	0.02–1.0	0.006–0.03	BLD– 0.24	This study
Lipstick	0.017–0.09	0.006–0.031	0.009–0.207	Adepoju-Bello et al. (2012)
Lipstick	BLD–0.03869	0.00093–0.15398	BLD–1.52	Al-Qahtani et al. (2016)
Lipstick	6.350–18.21	0.110–0.340	30–80	Nasirudeen and Amaechi (2015)
Lipstick	8.82–23.360	BLD–13.648	BLD– 8.325	Philip et al. (2018)
Lipstick	0.09–30.6	BLD	BLD	Al-Qutob et al. (2013)
Nail polish	1.0067–33.782	0.230–5.890	BLD	Karim and Ziarati (2015)
Nail polish	BLD–42.14	0.16– 0.52	ND	Ouremi and Ayodele (2014)
Nail polish	4.15–85.55	ND	ND	Ackah et al. (2015)
Nail polish	6.6–39.5	ND	ND	Mahugija (2018)

BLD = Below detection limit; ND = Not determined

Higher values than the values observed elsewhere indicate that using the products sold in Tanzania exposes consumers to a higher dose of the heavy metals compared to other areas and vice versa. In addition, there is possibility that the types of cosmetic brands sold in Tanzania are different from those sold in other countries, which makes this comparison more or less unrealistic.

Estimated daily intake of cosmetics from lipsticks

The estimated daily intake of cosmetics were determined using the chronic daily intake. The CDI for Pb in lipsticks ranged from 1.68 x 10^{-6} to 8.39 x 10^{-5}, while that of As ranged from 5.87 x 10^{-7} to 2.9 x 10^{-6}. Furthermore, CDI for Hg ranged from 4.40 x 10^{-5} to 2.12 x 10^{-3} (Table 7). The CDI for Pb in nail polish ranged from 1.68 x 10^{-7} to 7.55 x 10^{-6}. Similarly, CDI for As ranged from 5.90 x 10^{-6} to 3.13 x 10^{-5}, while that of Hg ranged from 4.40 x 10^{-3} to 6.43 x10^{-3} (Table 8). Corresponding CDI of the metals were more or less the same in both types of cosmetics. The determined CDIs for Pb, As, and Hg in the lipsticks and nail polishes were lower than the maximum tolerable daily intake (MTDI), implying minimal health risks to users.

Table 7: Chronic daily intakes, hazard quotient, hazard index and total risk for metals in analysed lipstick cosmetics

	CDI = ∑CD			HQ				Total risk		
Code	Pb (x 10^{-5})	As (x 10^{-6})	Hg (x 10^{-4})	Pb (x 10^{-4})	As (x 10^{-5})	Hg (x 10^{-1})	HI (x 10^{-1})	Pb (x 10^{-8})	As (x 10^{-10})	Hg (x 10^{-9})
LS01	0.92	0.59	0.44	2.31	1.47	0.34	0.34	3.23	1.76	3.88
LS02	1.12	1.96	4.40	2.81	4.89	3.39	3.39	3.93	5.87	38.76
LS03	1.17	0.59	0.44	2.94	1.47	0.34	0.34	4.11	1.76	3.88
LS04	1.51	0.98	6.16	3.78	2.45	4.74	4.74	5.28	2.94	54.27
LS05	1.34	0.59	0.44	3.36	1.47	0.34	0.34	4.70	1.76	3.88
LS06	0.59	0.59	0.44	1.47	1.47	0.34	0.34	2.06	1.76	3.88
LS07	2.01	0.59	0.44	5.03	1.47	0.34	0.34	7.05	1.76	3.88
LS08	1.26	0.59	0.44	3.15	1.47	0.34	0.34	4.40	1.76	3.88
LS09	1.09	1.96	0.44	2.73	4.89	0.34	0.34	3.82	5.87	3.88
LS10	1.09	0.59	0.88	2.73	1.47	0.68	0.68	3.82	1.76	7.75
LS11	8.39	0.98	0.88	20.97	2.45	0.68	0.70	29.36	2.94	7.75
LS12	1.09	0.59	0.44	2.73	1.47	0.34	0.34	3.82	1.76	3.88
LS13	0.17	0.59	0.88	0.42	1.47	0.68	0.68	0.59	1.76	7.75
LS14	0.92	1.96	0.88	2.31	4.89	0.68	0.68	3.23	5.87	7.75
LS15	0.92	0.59	0.44	2.31	1.47	0.34	0.34	3.23	1.76	3.88
LS16	1.85	0.59	21.12	4.61	1.47	16.25	16.25	6.46	1.76	186.07
LS17	0.76	2.94	1.76	1.89	7.34	1.35	1.36	2.64	8.81	15.51
LS18	1.93	0.98	0.44	4.82	2.45	0.34	0.34	6.75	2.94	3.88
LS19	1.09	0.59	7.04	2.73	1.47	5.42	5.42	3.82	1.76	62.02
LS20	1.59	0.59	2.64	3.98	1.47	2.03	2.04	5.58	1.76	23.26
LS21	4.19	2.94	0.44	10.49	7.34	0.34	0.35	14.68	8.81	3.88
LS22	2.18	0.59	0.44	5.45	1.47	0.34	0.34	7.63	1.76	3.88
LS23	3.36	0.59	1.76	8.39	1.47	1.35	1.36	11.74	1.76	15.51
LS24	0.92	0.98	0.44	2.31	2.45	0.34	0.34	3.23	2.94	3.88
LS25	3.10	0.59	0.44	7.76	1.47	0.34	0.35	10.86	1.76	3.88

Table 8: Chronic daily intakes, hazard quotient, hazard index and total risk for metals in analysed nail polish cosmetics

	CDI =∑CD			HQ				Total risk		
Code	Pb (x 10^{-6})	As (x 10^{-5})	Hg (x 10^{-3})	Pb (x 10^{-4})	As (x 10^{-4})	Hg(x 10^{-1})	HI(x 10^{-1})	Pb (x 10^{-8})	As (x 10^{-9})	Hg (x 10^{-7})
NP01	0.84	0.59	1.23	0.21	1.47	0.95	0.95	0.29	1.76	1.09
NP02	1.68	0.20	0.04	0.42	0.49	0.03	0.03	0.59	0.59	0.04
NP03	0.84	0.06	1.41	0.21	0.15	1.08	1.08	0.29	0.18	1.24
NP04	1.68	0.06	1.41	0.42	0.15	1.08	1.08	0.59	0.18	1.24
NP05	0.17	1.08	0.62	0.04	2.69	0.47	0.47	0.06	3.23	0.54
NP06	7.55	3.13	0.35	1.89	7.83	0.27	0.27	2.64	9.39	0.31
NP07	0.84	0.10	6.43	0.21	0.25	4.94	4.94	0.29	0.29	5.66
NP08	0.84	2.06	0.26	0.21	5.14	0.20	0.20	0.29	6.17	0.23
NP09	0.84	1.86	0.04	0.21	4.65	0.03	0.03	0.29	5.58	0.04
NP10	0.17	0.29	2.91	0.04	0.73	2.23	2.23	0.06	0.88	2.56
NP11	1.68	0.78	0.44	0.42	1.96	0.34	0.34	0.59	2.35	0.39
NP12	0.17	0.20	3.52	0.04	0.49	2.71	2.71	0.06	0.59	3.10
NP13	0.17	0.49	0.79	0.04	1.22	0.61	0.61	0.06	1.47	0.70
NP14	0.17	0.20	0.35	0.04	0.49	0.27	0.27	0.06	0.59	0.31
NP15	0.17	0.20	0.04	0.04	0.49	0.03	0.03	0.06	0.59	0.04

Carcinogenic and non carcinogenic risks of lipsticks and nail polishes

The health risks of using the lipstick and nail polish cosmetics were evaluated using the HQ. Values of HQ > 1 are indicative of high potential risk, whereas values of HQ < 1 are indicative of unlikely exposure risk (Alam et al. 2019). The findings have indicated that HQ of the Pb and As were < 1 (Table 7), indicating that the users of the brands of the analysed lipstick cosmetics have no significant health risks through ingesting, dermal contact or inhaling the cosmetic. Similarly, HQs of Hg in the selected lipsticks were < 1 except one product that had HQ of 1.63 (Table 7). Whereas using this product poses a potential health risk, using other lipstick products poses little risk. HQs of all metals in the selected nail polish cosmetics were < 1, indicative of the little potential health risks of using the selected nail polish products.

A combined non-carcinogenic risk detemined by HI has indicated that users of the selected lipstick and nail polish brands are relatively safe. The potential carcinogenic risks of using the lipstick and nail polish cosmetics were also determined. Carcinogenic risks in the range 1×10^{-6} to 1×10^{-4} are usually acceptable (Chen and Liao 2006). Total risks of using lipsticks ranged from 1.76×10^{-10} (As) to 1.86×10^{-7} (Hg). Similarly, the total risk of using the selected nail polishes ranged from 1.8×10^{-10} As to 5.66×10^{-7} Hg. The risk levels observed are lower than the acceptable limit, which is indicative that potential carcinogenic risk is relatively small. However, heavy metals and particularly Pb is known to be a potential toxicant on a cumulative basis. Studies have revealed that the presence of lead in cosmetics can cause anaemia, colic, neuropathy, nephropathy, sterility, coma, behavioural abnormalities and learning impairment among others. Acute exposure to As may result to skin disorders, alopecia and characteristic striation of the nails. Further exposure of As can cause liver enlargement, damage to nervous system, hyper-pigmentation, anorexia, keratosis, leukaemia, kidney cancer, and bladder cancer, dermatitis and death (Deshpande 2005). The presence of Hg in cosmetics may lead to toxicity of the nervous, reproductive, immune as well as respiratory systems. Continuous use of lipstick and nail polish cosmetics may be feared as there could be long term exposure to the harmful heavy metals (Chauhan et al. 2010). Furthermore, the combined uses of these cosmetics may aggravate the dangers.

Conclusion

The levels and health risks of Pb, As, and Hg in lipstick and nail polish cosmetics were investigated. Pb was detected in all lipsticks and more than 53% of all nail polishes. Arsenic (As) was detected in 36% of all lipsticks and 86.7% of all nail polishes, Hg was detected in more than 44% of lipsticks and 80% of all nail polishes. The levels of Pb, As and Hg in lipsticks and nail polishes were found to be lower than the respective maximum recommended limits according to the WHO and TBS. The chronic daily intake, non-carcinogenic and carcinogenic estimated risks of the selected heavy metals in analysed lipsticks and nail polishes have indicated that the analysed cosmetic products are relatively safe. However, since heavy metals can accumulate, continuous use and exposure might pose health risks in the future. This is particularly more pronounced when other heavy metals of health concern are also considered. Hence, continuous monitoring of the cosmetics is recommended in a way to control the quality of products and safety of the consumers. Awareness of the potential effects is also needed to users of the cosmetics.

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