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Research article

Human health risks of lead, cadmium, and other heavy metals in lipsticks

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ABSTRACT

The study investigates the concentration of heavy metals in various lipsticks sold in Ghana and assesses the potential health risks associated with their use. A total of 12 lipstick samples were analyzed using an X-ray fluorescence (XRF) analyzer for metals, including chromium (Cr), manganese (Mn), nickel (Ni), copper (Cu), cadmium (Cd), and lead (Pb). The findings revealed that Cr levels ranged from below detection limits to 2554.20 mg/kg, with five samples significantly exceeding the acceptable 1 mg/kg limit set by Health Canada. Mn concentrations varied from 0.09 mg/kg to 823.00 mg/kg, and Ni levels were detected up to 228.40 mg/kg, indicating potential risks of neurotoxicity and contact dermatitis. Cu was found in extremely high concentrations, particularly in samples S1 (14053.33 mg/kg) and S7 (1939.84 mg/kg), exceeding the acceptable 100 mg/kg limit, suggesting severe contamination and potential systemic toxicity. Cd concentrations in most samples surpassed the FDA limit of 3 mg/kg, posing risks of kidney damage. In comparison, Pb concentrations in several samples approached or exceeded the FDA limit of 10 mg/kg, indicating potential neurotoxic effects. Health risk assessments for dermal and oral exposure were conducted, with hazard quotients for non-carcinogenic risks remaining below 1, suggesting minimal immediate health risks. However, the relative intake indices (RII) for Cr, Cd, and Pb in oral risk assessments indicated significant exposure levels far exceeding acceptable daily intakes (ADI) for heavy users. These findings highlight the need for stricter regulation and consumer awareness of the potential dangers posed by heavy metals in cosmetics. Enhanced safety standards and regular monitoring are imperative to protect public health from the adverse effects of toxic metals in beauty products.

1. Introduction

The use of cosmetics, particularly lipsticks, has increased globally, raising concerns about the safety of these products due to potential contamination by heavy metals [1]. Heavy metals, such as lead, chromium, and cadmium, are common contaminants in cosmetic products and can accumulate in the human body through skin contact and ingestion. Prolonged exposure to these metals can cause severe health effects, including neurotoxicity, carcinogenicity, and organ damage [2]. For example, lead exposure has been linked to cognitive impairments, especially in children and pregnant women [3], while cadmium can lead to kidney damage [4].

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Lipsticks are one of the most commonly used cosmetics worldwide, which raises concerns regarding possible heavy metal exposure through skin contact and unintentional ingestion [5,6].

The two main ways that heavy metals in cosmetics can enter the body and perhaps have a negative impact on health are through skin contact and oral consumption [7]. While prolonged exposure to Cr may raise the risk of cancer, long-term Pb exposure can cause endocrine disruption and renal disorders [4,8,9]. Cadmium can build up in organs, resulting in nausea, cramping in the abdomen, and diarrhoea [6]. Recent studies have highlighted the molecular mechanisms of cadmium-induced cytotoxicity, emphasizing its harmful effects on human cells [10].

The growing use of cosmetics and the yearning for beauty have raised concerns about these items' safety. Research has indicated that people may inadvertently consume a significant quantity of lipstick throughout their lifetime, potentially aggravating the negative consequences of chemical pollutants such as heavy metals [1,11–15]. Lead (Pb), chromium (Cr), and cadmium (Cd) are among the heavy metals of concern in cosmetics, each posing specific health risks upon exposure [16–19].

It is critical to evaluate the levels of heavy metal contamination in frequently used items due to the possible health hazards connected with cosmetics exposure. Manufacturers often incorporate heavy metals like lead and mercury into cosmetics to enhance their performance [20–24], such as providing whitening effects or inhibiting pigment formation. The risk of exposure is further increased by heavy metals in raw materials used in cosmetics, which result from natural processes and environmental pollution.

Research has indicated that extended exposure to low concentrations of heavy metals might result in detrimental health consequences, such as long-term poisoning and possible carcinogenicity, hence presenting a substantial risk to human health [3,25–27]. Lip cosmetics, in particular, are a popular choice among modern women for enhancing their appearance and moisturizing their lips. Due to direct contact with the lips and potential ingestion, lip products present a higher health risk than other cosmetics.

Despite the known risks, there is a lack of comprehensive regulation governing the levels of heavy metals in cosmetics sold in many countries, including Ghana. Studies from Iran, Nigeria, and Pakistan have also raised concerns over the safety of cosmetics due to high levels of heavy metals [15,24]. This study aims to fill the research gap by assessing the concentration of heavy metals in lipsticks from the Ghanaian market and evaluating the associated health risks.

2. Materials and methods

2.1. Sampling and sample preparation

A total of 12 lipstick samples were purchased from local markets in Ghana, with brands from both locally produced and imported products included. The lipsticks were broken into small pieces and pulverized using a clean, sterile mortar and pestle to ensure sample homogeneity. Samples were then sealed in labeled Ziploc bags prior to analysis.

Each lipstick sample was carefully weighed (1.5 g) and transferred to sample holders covered with Mylar film for XRF analysis. This method was chosen for its efficiency in detecting trace elements [7].

2.2. Metal analysis

Heavy metal concentrations in the samples were determined using a Niton XRF analyzer (Thermo Scientific Mobile Test S, NDTr-XL3t-86956, com 24). The XRF analyzer settings included a 180-s scan with calibration against standard discs for accurate measurement. All analyses were conducted in triplicate to ensure consistency. The specific trace elements analyzed were lead (Pb), arsenic (As), mercury (Hg), zinc (Zn), iron (Fe), manganese (Mn), chromium (Cr), titanium (Ti), copper (Cu), nickel (Ni), cobalt (Co), antimony (Sb), cadmium (Cd), silver (Ag), tin (Sn), and gold (Au). The limit of detection (LOD) for each metal was set based on prior studies using similar methods, with Cr at 1 mg/kg and Cd at 0.5 mg/kg [7,28]. The reported results represent the average concentration values obtained from these three analyses.

2.3. Dermal risk assessment of lipsticks

Heavy metals found in lipsticks can enter the body through skin contact. To assess the risk, we calculate lipstick's chronic daily intake (CDI) based on the following criteria (Eq. (1))

$$CDI_{dermal} = \frac{CS \times SA \times AF \times ABS \times EF \times ED \times CF}{BW \times AT} \quad \text{EQ 1}$$

CS: Metal concentration in lipsticks (milligrams per kilogram, mg/kg)
SA: Exposed skin area (5700 square centimetres, cm^2) [6,29].
AF: Adherence factor (0.07 mg per square centimetre, mg/cm^2)
ABS: Dermal absorption fraction (0.001) [26].
EF: Frequency of exposure (350 days per year, days/year)
ED: Duration of exposure (30 years)
BW: Body weight (70 kg, kg)
AT: Average time for non-carcinogens (calculated by dividing ED by 365 days)
CF: Conversion factor (10^{-6} kg per milligram, kg/mg) [6].

A Hazard Quotient (HQ) is used to evaluate the potential non-cancer health risks from exposure to heavy metals through various pathways (e.g., ingestion, inhalation, skin contact). It is calculated by dividing the Chronic Daily Intake (CDI) by the Reference Dermal Dose (RFD). The RFD represents the safe level of daily exposure to a specific metal over a lifetime that is unlikely to cause adverse health effects.

HQ greater than 1 (HQ > 1): This indicates a potential health risk for the exposed person. However, it doesn't necessarily guarantee harm; further evaluation may be needed.

HQ less than 1 (HQ < 1): This suggests minimal to no risk of adverse health effects from current exposure levels.

Equation (2) is used to obtain the carcinogenic risk value:

$$\text{Carcinogenic risk } (CR) = CDI \times SF \; EQ \; 2$$

SF is the slope factor (mg kg^{-1} d^{-1}).

Carcinogenic risk (CR) values between 10^{-6} and 10^{-4} are acceptable, while CR less than 10^{-6} is considered insignificant. On the other hand, CR more than 10^{-4} suggests a significant cancer risk.

Oral risk assessment of lipsticks.

Consumers use 25.7–149.02 mg of lipstick daily [27]. Heavy users consumed an estimated 149.02 mg/adult/day, whereas average users consumed 25.7 mg/adult/day, assuming all applied lip products were swallowed. Estimated acceptable daily intakes (ADIs) were considered to evaluate potential harmful health effects [27].

By dividing the metal concentration released from the expected amount of product consumed by the mean body weight, the estimated daily intake (EDI) was determined, as shown in Equation (3).

$$EDI\left(\mu gkg^{-1}\ b.w\ day^{-1}\right) = \frac{\left(MC\left(\mu gg^{-1}\right) \times W_p\left(mgday^{-1}\right)\right)}{BW} \text{ EQ 3}$$

MC: Metal concentration (in μg/g)

Wp: Weight of product intake (in mg/day)

BW: Body weight (in kg)

The derived ADIs and metal intakes from lip cosmetics were compared. For metals from lip products, relative intake indices (RIIs) were computed, showing the ADI proportion in percentage (Eq. (4)) [6].

$$RII\% = \frac{EDI}{ADI} \times 100 \qquad \text{Eq.4}$$

2.4. Statistical analysis

The data analysis software Microsoft Excel 2019 was utilized to calculate and report the mean and standard deviation for each element detected in the samples. Additionally, the software was employed to determine the minimum and maximum concentration values for each element across all analyzed samples.

3. Results and discussion

The heavy metal concentrations in the lipstick samples are presented in Table 1. The results show several findings of concern, particularly when compared to the acceptable limits set by regulatory bodies such as the FDA and Health Canada [14,26,30].

Chromium concentrations ranged from BDL to 2554.20 mg/kg. The concentrations in samples S4 (583.00 mg/kg), S6 (2554.20 mg/kg), S7 (613.60 mg/kg), S8 (1184.67 mg/kg), and S11 (1380.00 mg/kg) significantly exceeded the acceptable limit of 1 mg/kg established by Health Canada. Such high levels of chromium can lead to skin irritation, allergic reactions, and long-term exposure risks, including carcinogenic effects.

While the acceptable limits for manganese in cosmetics are not well-defined, its presence in high concentrations in samples S5

Table 1
Heavy metal concentrations (mg/kg) in lipstick.

Sample	Cr	Mn	Ni	Cu	Zn	As	Cd	Hg	Pb	Fe
S1	34.33	56.00	18.00	14053.33	BDL	BDL	26.00	BDL	6.33	4894.00
S2	BDL	BDL	5.67	BDL	BDL	BDL	23.33	BDL	BDL	4095.67
S3	BDL	BDL	BDL	BDL	BDL	BDL	27.67	BDL	BDL	236.67
S4	583.00	85.67	55.33	BDL	12.67	BDL	25.00	BDL	BDL	5248.00
S5	BDL	368.67	BDL	BDL	13.67	BDL	17.33	BDL	8.00	3965.00
S6	2554.20	143.00	228.40	7.00	31.80	BDL	18.00	BDL	BDL	5491.60
S7	613.60	109.80	58.15	1939.84	17.14	BDL	22.18	BDL	1.98	5436.73
S8	1184.67	823.00	112.67	24.67	619.33	BDL	BDL	BDL	14.00	14152.00
S9	182.00	BDL	14.00	BDL	BDL	BDL	32.00	BDL	BDL	1053.67
S10	BDL	BDL	BDL	BDL	4.67	BDL	22.33	BDL	BDL	22018.67
S11	1380.00	320.00	155.00	BDL	52.00	BDL	BDL	BDL	11.33	111247.67
S12	BDL	BDL	BDL	BDL	BDL	BDL	25.67	BDL	0.67	272.33

BDL – Below detection limit; Mean concentrations of the heavy metals are presented in Table 1.

(368.67 mg/kg) and S8 (823.00 mg/kg) is concerning. Manganese is essential in small amounts, but excessive exposure can result in neurotoxicity, adversely affecting the nervous system.

Nickel concentrations in samples S1 (18.00 mg/kg), S4 (55.33 mg/kg), S6 (228.40 mg/kg), S7 (58.15 mg/kg), S8 (112.67 mg/kg), and S11 (155.00 mg/kg) exceed the FDA's acceptable limit of 10 mg/kg [31]. Nickel is a known allergen and can cause contact dermatitis and other hypersensitivity reactions, posing significant risks to users with prolonged exposure [32,33].

Copper levels in samples S1 (14053.33 mg/kg) and S7 (1939.84 mg/kg) were far above the acceptable limit of 100 mg/kg set by Health Canada [30]. Excessive copper exposure can lead to systemic toxicity, including liver and kidney damage, highlighting a severe contamination issue in these samples.

Although the acceptable limits for zinc in cosmetics are not well-defined, the high concentration in sample S8 (619.33 mg/kg) is notable. Zinc is generally considered safe, but excessive levels could indicate contamination and potential health risks with long-term use.

Cadmium levels in most samples exceeded the FDA's acceptable limit of 3 mg/kg. Notably, samples S1 (26.00 mg/kg), S2 (23.33 mg/kg), S3 (27.67 mg/kg), S4 (25.00 mg/kg), S6 (18.00 mg/kg), S7 (22.18 mg/kg), S9 (32.00 mg/kg), S10 (22.33 mg/kg), and S12 (25.67 mg/kg) all show significant cadmium contamination. Cadmium is highly toxic and can cause kidney damage, bone demineralization, and other severe health issues with chronic exposure [9,34].

Lead concentrations in sample S8 (14.00 mg/kg) exceed the FDA's acceptable limit of 10 mg/kg. Samples S1 (6.33 mg/kg), S5 (8.00 mg/kg), and S11 (11.33 mg/kg) approach this limit, indicating potential risk. Lead is a potent neurotoxin affecting cognitive development and function, especially in children and pregnant women.

No specific limits are set for Fe in cosmetics, but it should be monitored for overall quality and safety. Samples S1, S4, S6, S7, S8, S10, and S11 had significantly high Fe concentrations, with S11 reaching 111247.67 mg/kg. While Fe is not highly toxic, high levels could indicate contamination and affect product quality.

No arsenic or mercury was detected in any of the samples, which is a positive outcome, as these metals are highly toxic and can cause severe health problems even at low levels of exposure.

The Pearson's correlation analysis of heavy metals in the lipstick samples is presented in Table 2.

Cr and Ni showed an extremely high positive correlation (0.99), indicating that these metals likely co-occur. This suggests a common source or similar pathways of contamination. A moderate positive correlation (0.40) between Cr and Mn indicated that these metals may share some common sources but to a lesser extent than Cr and Ni.

Mn had a very high positive correlation with Zn (0.89), suggesting a strong likelihood that these two metals are introduced into the products from similar sources. A high positive correlation (0.88) between Mn and Pb also indicates that these metals tend to be found together, pointing to a possible common source of contamination. Mn and Cd showed a strong negative correlation (−0.85), suggesting that one of these metals might suppress the presence of the other.

A strong positive correlation (0.69) between Zn and Pb indicated a tendency to co-occur and potentially share common contamination sources. Zn and Cd showed a moderate negative correlation (−0.68), suggesting an inverse relationship in their presence in the samples. The strong negative correlations of Cd with Cr, Mn, Ni, Zn, and Pb suggest that Cd contamination may occur through different sources or mechanisms than these metals.

Cd and Pb had a strong negative correlation (−0.85), indicating that these metals are rarely found together in high concentrations.

Fe showed moderate correlations with several metals, including a positive correlation with Ni (0.44) and Pb (0.52), but generally weaker relationships with the other metals.

The analysis of variance (ANOVA) of the heavy metal concentrations in lipsticks is presented in Table 3.

The ANOVA (Analysis of Variance) results determined if there were statistically significant differences in the concentrations of various heavy metals across the lipstick samples.

Cr showed a relatively high mean concentration with a large variance, indicating significant sample variability. Mn had a lower average concentration than Cr but still showed considerable variability. Ni had a moderate average concentration and lower variability than Cr and Mn. Cu had a high average concentration with very high variability, indicating inconsistent sample distribution. Zn had a moderate average concentration with lower variability. Cd showed a lower average concentration with minimal variability. Pb had a very low average concentration with minimal variability. Fe had the highest average concentration, with extremely high variability, indicating substantial differences among samples. Hg and As were not detected in any samples.

The F-value (2.639) is greater than the critical F-value (1.966), and the P-value (0.008) is less than the significance level (typically 0.05). This indicates statistically significant differences in the concentrations of heavy metals among the lipstick samples.

Table 2
Pearson's correlation analysis of heavy metals in lipstick.

	Cr	Mn	Ni	Cu	Zn	Cd	Pb	Fe
Cr	1.00							
Mn	0.40	1.00						
Ni	0.99	0.42	1.00					
Cu	−0.20	−0.14	−0.15	1.00				
Zn	0.32	0.89	0.32	−0.12	1.00			
Cd	−0.56	−0.85	−0.61	0.20	−0.68	1.00		
Pb	0.24	0.88	0.31	0.16	0.69	−0.85	1.00	
Fe	0.35	0.27	0.44	−0.11	0.06	−0.69	0.52	1.00

Table 3
One-way analysis of variance (ANOVA).

SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Cr	12	6531.80	544.32	638827.50		
Mn	12	1906.14	158.84	59622.25		
Ni	12	647.22	53.93	5543.02		
Cu	12	16024.84	1335.40	16350926.23		
Zn	12	751.28	62.61	30992.48		
As	12	0.00	0.00	0.00		
Cd	12	239.52	19.96	102.57		
Hg	12	0.00	0.00	0.00		
Pb	12	42.31	3.53	25.79		
Fe	12	178112.00	14842.67	960221064.99		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2321333721	9	257925969	2.639	0.008	1.966
Within Groups	10750378153	110	97730710.48			
Total	13071711875	119				

The significant F-value suggests that the variation between groups (different metals) is greater than within groups (samples of the same metal). This implies that the types of metals contribute more to the observed variability in concentrations than the individual samples.

The significant differences highlight the need for careful monitoring and regulation of heavy metal content in cosmetic products. Certain metals, such as Cu and Fe, exhibit high average concentrations and variances, indicating potential contamination or inconsistent quality control during manufacturing.

4. Risk assessment

The non-cancer and cancer risk assessments of exposure to heavy metals are presented in Table 4 (dermal) and 5 (oral).

The dermal risk assessment indicates that most heavy metals in the lipstick samples do not pose significant non-cancer or cancer risks under typical usage scenarios. The Hazard Quotient for all metals is below 1, suggesting negligible non-cancer health risks. The calculated cancer risks for Cr, Ni, and Cd are low and fall within acceptable ranges.

The oral risk assessment evaluates the potential health risks associated with the ingestion of heavy metals through the use of lipstick. This analysis considers the Estimated Daily Intake (EDI) for heavy and average users, the Acceptable Daily Intake (ADI), and the Relative Intake Index (RII), which expresses the EDI as a percentage of the ADI.

The RII values for Chromium (Cr) were high, with 1,158,773.24 % for heavy users and 199,842.12 % for average users. These values indicate a significant risk of exposure above the safe limits, especially for heavy users, posing a severe health risk and suggesting the need for immediate regulatory attention [1]. Manganese (Mn) also showed high RII values, with 18,786.55 % for heavy users and 3239.93 % for average users, suggesting a significant risk of overexposure that could lead to neurological and other health issues [27].

Cadmium (Cd) recorded high RII values, with 11,181.97 % for heavy users and 1928.44 % for average users. These values indicate a severe risk of overexposure, which can lead to kidney damage and other serious health problems [35]. Lead (Pb) also recorded high RII values, with 790.11 % for heavy users and 136.26 % for average users, suggesting significant health risks, particularly for heavy users. Lead exposure is associated with neurological damage and other health problems [3]. Iron (Fe) showed excessively high RII values, with 6319.58 % for heavy users and 1089.88 % for average users, indicating a substantial risk of iron overload, which can cause liver

Table 4
Dermal risk assessment of exposure to heavy metals in lipstick.

Metal	Mean Conc. (mg/kg)	Chronic Daily Intake (CDI_{dermal})	Reference Dose (RFD) (mg $kg^{-1}day^{-1}$)	Hazard Quotient = CDI/RFD	Slope Factor (mg/kg/d)	Cancer Risk
Cr	544.32	2.9751E-06	0.005	5.95E-04	0.5	1.48755E-06
Mn	158.84	8.68207E-07	0.14	6.20E-06		
Ni	53.93	2.94795E-07	0.0008	3.68E-04	0.91	2.68263E-07
Cu	1335.40	7.29898E-06	0.04	1.82E-04		
Zn	62.61	3.42191E-07	0.3	1.14E-06		
As	BDL	–	0.0003	0	1.5	
Cd	19.96	1.09095E-07	0.001	1.09E-04	6.7	7.30938E-07
Hg	BDL	–	0.0001	0		
Pb	3.53	1.92715E-08	0.0004	4.82E-05	0.0085	1.63808E-10
Fe	14842.67	8.11264E-05	0.007	1.16E-02		

Table 5
Oral risk assessment of exposure to heavy metals in lipstick.

Metal	EDI (Heavy User)	EDI (Average User)	ADI	RII(%) (Heavy User)	RII% (Average User)
Cr	1158.77	199.84	0.1	1158773.24	199842.12
Mn	338.16	58.32	1.8	18786.55	3239.93
Ni	114.82	19.80	56	205.04	35.36
Cu	2842.88	490.28	7100	40.04	6.91
Zn	133.28	22.99	500	26.66	4.60
As	0.00	0.00	130	0.00	0.00
Cd	42.49	7.33	0.38	11181.97	1928.44
Hg	0.00	0.00	40	0.00	0.00
Pb	7.51	1.29	0.95	790.11	136.26
Fe	31597.92	5449.38	500	6319.58	1089.88

damage and other serious health issues [30].

Nickel (Ni) poses a risk for heavy users with RII values of 205.04 %, indicating potential exceedance of the safe intake level. However, the risk for average users is relatively low at 35.36 % [20]. In contrast, Copper (Cu) and Zinc (Zn) exhibit RII values well below 100 %, with Cu at 40.04 % for heavy users and 6.91 % for average users, and Zn at 26.66 % for heavy users and 4.60 % for average users. These values suggest that both heavy and average users are unlikely to exceed the safe intake levels, indicating minimal risk from exposure through lipstick use [36].

Arsenic (As) and Mercury (Hg) were not detected in the samples, indicating no risk from these metals.

The implications of heavy metal contamination extend beyond human health, affecting aquatic ecosystems, as demonstrated in studies evaluating coastal aquaculture activities [37].

The study's limitations include the relatively small sample size (12 lipsticks) and its restriction to products available in local markets, which may not represent the entire range of products used by consumers in Ghana. Additionally, XRF analysis may have limitations in sensitivity compared to methods such as ICP-MS, especially for low-concentration metals.

5. Conclusion

The assessment of heavy metal concentrations in lipstick samples procured from the Ghanaian market reveals significant health risks associated with their use. The analysis identified levels of heavy metals such as chromium (Cr), manganese (Mn), nickel (Ni), copper (Cu), cadmium (Cd), and lead (Pb) in several lipstick samples, exceeding acceptable limits set by regulatory bodies like Health Canada and the FDA.

Chromium concentrations ranged from below detection limits to 2554.20 mg/kg, with five samples significantly exceeding the acceptable 1 mg/kg limit, posing risks such as skin irritation, allergic reactions, and potential carcinogenic effects. Manganese and nickel levels were also notably high, with Mn concentrations reaching 823.00 mg/kg and Ni reaching 228.40 mg/kg. These levels raise concerns about neurotoxicity and contact dermatitis.

Copper was found in extremely high concentrations, particularly in samples S1 (14053.33 mg/kg) and S7 (1939.84 mg/kg), far surpassing the acceptable 100 mg/kg limit. This indicates severe contamination, potentially leading to systemic toxicity, including liver and kidney damage. Similarly, cadmium concentrations in most samples exceeded the FDA's acceptable limit of 3 mg/kg, highlighting risks of kidney damage and bone demineralization.

Lead concentrations in several samples approached or exceeded the FDA limit of 10 mg/kg, indicating a potential risk of neurotoxicity, especially for vulnerable populations such as children and pregnant women. The presence of these heavy metals, particularly in products intended for daily use, underscores the need for stringent regulation and monitoring to protect consumer health.

The risk assessments conducted for both dermal and oral exposure to these heavy metals indicate that while the hazard quotients for non-carcinogenic risks are below 1, suggesting minimal immediate health risks, the potential for long-term health impacts cannot be ignored. Oral risk assessment, particularly for heavy users, shows exceedingly high relative intake indices (RII) for Cr, Cd, and Pb, indicating significant exposure levels far exceeding acceptable daily intakes (ADI).

This study highlights the urgent need for stricter regulation of heavy metals in cosmetics sold in Ghana. The findings indicate significant contamination of lipsticks with heavy metals such as chromium, cadmium, and lead, posing long-term health risks. While non-carcinogenic risks are minimal under typical use, heavy users are exposed to metal levels exceeding acceptable daily intakes, particularly for Cr and Cd. Regulatory bodies should enforce stringent safety standards and conduct regular monitoring to protect consumers. Consumers should also be educated about the potential risks of heavy metal exposure through cosmetics, promoting safer choices and practices.

CRediT authorship contribution statement

Selina Ama Saah: Writing – review & editing, Supervision, Conceptualization. **Nathaniel Owusu Boadi:** Writing – review & editing, Writing – original draft, Validation, Resources, Methodology. **Patrick Opare Sakyi:** Writing – review & editing, Supervision. **Euphemia Quanuaa Smith:** Writing – review & editing, Methodology, Investigation.

Ethics statement

This study adhered to all applicable ethical standards in its design, conduct, and reporting. The research focused on analyzing commercially available lipsticks for heavy metal contamination to evaluate potential health risks. No human or animal subjects were involved, eliminating the need for ethical approval from institutional review boards. The authors ensured that data collection, sample preparation, and analysis were conducted with accuracy and transparency. All results were reported honestly without fabrication, falsification, or inappropriate data manipulation. The study complies with relevant safety guidelines and scientific integrity principles.

Data availability

The data supporting this study's findings are available from the corresponding author upon reasonable request.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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