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Cosmetic Toxicology: Investigating Heavy Metal Contamination in Commercially Sold Make-up Cosmetics in Asaba, Nigeria.

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Abstract

This study aims to investigate the presence and concentrations of heavy metals in commonly used make-up cosmetics in Asaba, Southern Nigeria. A total of 50 cosmetic products, including foundation, powder, eyeshadow, eyeliner, and lipstick, were randomly selected from local markets and beauty shops. Atomic Absorption Spectroscopy (AAS) was employed to detect and quantify the levels of lead (Pb), nickel (Ni), cadmium (Cd), and chromium (Cr) in the samples. The results revealed that 70% of the products contained at least one heavy metal, with nickel and chromium being the most detected. In some cases, the levels of these metals exceeded the safe limits established by regulatory agencies, posing potential health risks to consumers. This study underscores the need for more stringent regulations and consistent monitoring of cosmetic products in Nigeria to prevent exposure to toxic heavy metals. It also highlights the importance of consumer awareness and education regarding the safe use of cosmetics.

Keyword: Cosmetic toxicology, Heavy metal contamination, Make-up cosmetics, Asaba, Southern Nigeria.

INTRODUCTION

Cosmetic products have become an integral part of daily life, with millions of people worldwide using various cosmetics to enhance their appearance. The global makeup industry has witnessed rapid expansion and diversification, driven by the increasing desire to align with evolving beauty trends and to conceal perceived skin imperfections (Ullah *et al*., 2013). In recent times, there has been an exponential rise in the use of makeup cosmetics by both males and females (Souiden & Diagne, 2009; Amasa *et al*., 2012; Yebpella *et al*., 2014; Wanjari & Waghmare, 2015). The adoption of queer culture and the emergence of androgynous fashion have further contributed to the growing use of cosmetics among men.

Cosmetics are broadly defined as products intended to be rubbed, poured, sprinkled, sprayed on, or otherwise applied to the human body for cleansing, beautifying, enhancing attractiveness, or altering appearance without affecting the body's structure or physiological functions (Alsaffar and Hussein, 2014). The global beauty market is typically segmented into five main product categories: skincare, haircare, color cosmetics (makeup), fragrances, and toiletries/others (Lopaciuk and Loboda, 2013). Color cosmetics include a wide range of products such as lipstick, lip gloss, powder, rouge, mascara, eyeliner, eye shadow, and nail polish (Adepoju-Bello *et al*., 2012; Alsaffar and Hussein, 2014; Klaschka, 2015; Sani *et al*., 2016). These products are composed of various natural and synthetic compounds. However, growing concerns have emerged regarding the safety of certain beauty and sanitary products. For instance, talcum powders, popularly used for feminine hygiene, have recently been linked to an increased risk of ovarian cancer (Omoyajowo *et al*., 2021), raising questions about the long-term health implications of cosmetic product use.

It is not surprising that heavy metals have been detected in several cosmetic products, particularly in color cosmetics like makeup. These metals occur naturally in the environment such as in rocks, water, air, and soil and can be found in the raw materials, such as pigments, used in the cosmetic industry (Adepoju *et al*., 2012; Omoyajowo *et al*., 2024). In some cases, the presence of heavy metals in cosmetics is a result of intentional use by manufacturers, while in others, they are unintended impurities introduced through raw materials or environmental pollution. As the use of cosmetics continues to rise, concerns regarding their safety have grown, particularly regarding the presence of toxic substances such as heavy metals. Heavy metals like lead, mercury, arsenic, cadmium, and chromium are known to be harmful to human health, even at low concentrations (Agency for Toxic Substances and Disease Registry, 2020). Cosmetic toxicology has become a growing issue, as many cosmetic products contain heavy metals that can be absorbed through the skin or ingested accidentally (Lerner *et al*., 2019). Prolonged exposure to these metals can result in a range of health problems, including skin irritation, neurotoxicity, and even cancer (World Health Organization, 2018).

The skin, as the largest organ of the human body, acts as a protective barrier, shielding the body from harmful microorganisms as well as physical and chemical agents (Chambers *et al*., 2020). However, it also can absorb substances that can enter the body, potentially affecting physiological processes and causing adverse effects, including toxicity (Yosipovitch *et al*., 2019). Lipophilic molecules, those without an electric charge and with a molecular weight below 500 Da, can passively penetrate the skin. Factors such as temperature and skin occlusion can further enhance this absorption, facilitating the entry of substances used in cosmetics (Magnano *et al*., 2021). Given the prolonged exposure to makeup cosmetics on the skin, there is a risk of transdermal absorption of potentially harmful substances, which can accumulate in the body over time. Cancer, one of the leading causes of death in developed countries, is particularly associated with certain toxic exposures. Makeup cosmetics, commonly used products, often come into direct contact with the skin for prolonged periods. Therefore, their ingredients must be safe and comply with established safety standards. The list of substances deemed unsafe for cosmetic use is continuously updated, driven by emerging scientific findings. Despite significant progress in toxicology, it is impossible to completely rule out the presence of harmful compounds in commercially available products (European Council Regulation, 2019). Ingredients with potential toxicity should be regarded as especially hazardous.

In Nigeria, the cosmetic industry is largely unregulated, with many products available in the

market without proper quality control or safety testing (National Agency for Food and Drug Administration and Control, 2020). This study aims to investigate the presence and levels of heavy metals in commonly used make-up cosmetics in Asaba, Southern Nigeria. Asaba, the capital city of Delta State, is a major commercial centre in Southern Nigeria, with a high demand for cosmetic products. However, there is limited research on the safety of cosmetics used in this region. This study seeks to bridge this knowledge gap by analysing the levels of heavy metals in cosmetic products commonly used in Asaba.

METHODS

The makeup products were procured from local dealers and stores within Asaba in the popular Ogbeogonogo market. The products were all imported products from overseas especially United States and China. The study was concentrated on the five most used makeup product in Nigeria which are foundation (FD), powder (PD), Lip stick (LS), eye shadow (ES) and eye liner (EL). Five different types of cosmetic makeup from different brands were analysed with a sample size of 10 each. The criterion for selection was based on fairly new brands with the fastest selling rates between 2023 and 2024.

Facial Cosmetic Samples

1. Foundation (FD)

Makeup foundation is a cosmetic product that has become an essential tool in the daily beauty routine of many individuals. It is applied to the skin to even out tone, conceal imperfections, and enhance appearance. Beyond its cosmetic benefits, foundation also offers some skincare advantages. Many foundations contain moisturizing ingredients, such as hyaluronic acid and glycerine, which help to hydrate the skin. Some foundations also contain sun protection factors (SPF), providing a layer of defence against harmful UV ray. The versatility of foundation is another significant advantage. It comes in various forms, including liquid, cream, powder, and stick, catering to different skin types and preferences. For this research purpose we are using the common liquid foundation. However, it is essential to note that foundation can also have some drawbacks. Some products may contain heavy metals, such as lead and mercury, which can be harmful to the skin and overall health. Additionally, improper application and removal techniques can lead to clogged pores, skin irritation, and other adverse effects.

2. Powder (PD)

Makeup powder is a versatile and essential product in the world of cosmetics. It serves multiple purposes, from setting makeup in place to controlling shine and adding a finishing touch to the skin. Another significant benefit of powder is its ability to control shine, many powders contain ingredients like silica and kaolin, which help to absorb excess oil and reduce shine. Powder also offers some skincare benefits. Many powders contain ingredients like antioxidants and vitamins, which help to nourish and protect the skin. Some powders also contain SPF, providing a layer of defence against harmful UV rays. It comes in various forms, including loose powder, pressed powder, and mineral powder. Loose powder is the most commonly used. It is the type of powder sample we are using for this research purpose.

3. Lipstick (LS)

Lipstick is a timeless and multifaceted cosmetic product that has been a staple in the beauty industry for centuries. It is a symbol of self-expression, confidence, and femininity, offering a wide range of colours and finishes to suit individual styles and preferences. It is applied on the mouth and gives it a colourful and succulent look. Beyond its aesthetic appeal, lipstick also holds cultural and historical significance. In ancient civilizations, lipstick was a status symbol, worn by royalty and high-ranking officials to signify wealth and power. In the 1920s, lipstick became a symbol of liberation and independence, as women began wearing bold colors to express their newfound freedom. Additionally, many lipsticks now contain nourishing ingredients like hyaluronic acid and vitamin E, providing hydration and protection to the lips. However, lipstick has also faced criticism and controversy over the years. Some have argued that it is a symbol of societal pressure and gender conformity, perpetuating unrealistic beauty standards and reinforcing harmful gender stereotypes. Others have raised concerns about the potential health risks associated with lipstick, such as the presence of harmful chemicals like lead and parabens.

4. Eye Shadow (ES)

Eye shadow is a vital component of makeup that has been used for centuries to enhance and transform the eyes. With its vast array of colours, textures, and finishes, eye shadow has become a staple in the beauty industry, offering countless possibilities for creativity and self-expression. One of the primary functions of eye shadow is to add depth and dimension to the eyes. In addition to its facial appeal, eye shadow has also played a significant role in history and culture. In ancient Egypt, eye shadow was used to signify status and wealth, with darker shades reserved for royalty and high-ranking officials. In the 1960s and 1970s, eye shadow became a symbol of counterculture and rebellion, with bold and bright colours worn as a statement of nonconformity. Nonetheless certain group of scholars have raised concerns about the potential health risks associated with eye shadow, such as the presence of harmful chemicals and allergens.

5. Eye Liner (EL)

Is an essential tool in the world of makeup, serving as a means of self-expression, creativity, and empowerment. One of the primary functions of eyeliner is to define and shape the eyes. By creating a precise line along the lash line, eyeliner adds depth and dimension, making the eyes appear larger and more prominent. The use of eye liner can be traced back to ancient Egypt, then it was used to signify status, wealth, and spiritual beliefs, with dark kohl liner worn by royalty and high-ranking officials. In recent years, eyeliner has evolved to include various formulas and tools, such as liquid, gel, and pencil liners, each offering unique benefits and effects. The pencil liner is used for the purpose of this research

Determination of Heavy Metals

Heavy metals which include Cadmium, Chromium, Lead and Nickel were evaluated in foundation, powder, lipstick, eye shadow, eyeliner samples using Atomic Absorption Spectrophotometer (Sahu *et al*., 2004). One gram of each sample was then placed in a clean dry 50 mL beaker while the lipstick sample was weighed directly into 50 mL beakers. Concentrated perchloric acid ($HClO_4$; 10 mL) was then added to each of the beaker containing the sample then covered with watch glasses. The resulting mixture was placed on a hot plate in fume hood and digestion was started at 50 – 60^oC for about two hours with intermittent addition of $HClO_4$ acid to prevent the mixture from drying out. The mixture was then allowed to cool, and 10 mL of nitric acid (HNO_3) was added to the perchloric acid digest in the beaker.

Digestion was thereafter continued for further 1 hour while ensuring that the sample was completely digested resulting in a clear solution. The digest was cooled, transferred to 25 mL volumetric flasks and made up to mark with distilled water. Blank samples consisting of the perchloric acid, nitric acid and distilled water were also digested along with each batch of the samples digested. The digests were filtered through Whattman No. 1 filter papers into acid pre-washed plastic bottles. The metal contents of each digest were determined by atomic absorption spectrophotometry using Analyst 200 AAS spectrophotometer.

Data Analysis

Descriptive statistics, including mean, median, standard deviation, and range, were calculated for each heavy metal contaminant to summarize the data and identify patterns. Inferential statistics, such as t-tests and ANOVA, were used to compare heavy metal levels between different types of cosmetics, brands, and sources, to identify significant differences. Results are expressed as Mean ± SEM (standard error of mean). All data were analysed using Statistical Package for the Social Science 20 for windows (SPSS v20). Data visualization techniques like graphs and charts were used to illustrate findings and facilitate understanding.

RESULTS

In the foundation sample Chromium was detected with the highest value in FD 3 (1.125 ± 0.0121mg/kg) and lowest value in FD1 (0.525 ± 0.003 mg/kg) as shown in the figure. FD1, FD3, FD4 and FD5 had no detectable Nickel concentration. FD2 has the highest concentration of Nickel (6.125 ± 0.0032 mg/kg). Pb was detected in negligible quantity in FD1, FD2, FD3 and FD5. The highest value was detected in FD4 (0.522 ± 0.004 mg/kg). Cd was undetected in all the FD samples.

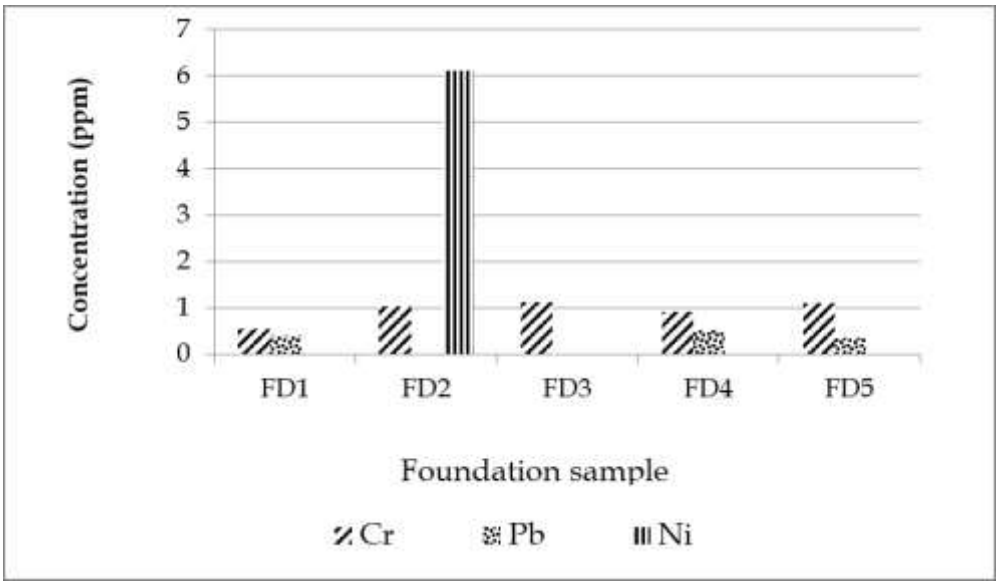

Figure 8: Heavy metal concentration in foundation samples

In the powder samples from the various brands of the cosmetic, Cadmium (Cd) was only detected in PW 5 with a concentration of 0.260 ± 0.024 mg/kg. Chromium (Cr), lead (Pb) and nickel (Ni) were detected at varying concentrations (Fig. 1). Cr was detected in PW2, PW 3 and PW 4 but was below detection level in PW 1 and PW 5. The highest concentration was obtained n PW 3 (0.665 ± 0.913 mg/kg) while the lowest detectable concentration was in PW 6 (0078 ± 0.076 mg/kg). Nickel was detected in PW 2, PW 3 and PW 4 but was not detected n PW1 and PW5 with the highest concentration obtained in PW 3 (7.915 ± 0.005 Mg/kg). In all the powder samples analysed, Pb was detected in PW 2, PW 3, PW 4 and PW 5 with highest concentration obtained n PW 4 (0.612 ± 0.002 mg/kg) while the lowest detectable concentration was in PW 5 (0.245 ± 0.004 mg/kg).

In lipstick Cr concentration was highest in LS 1(2.350 ± 0.011 mg/kg) and lowest in LS 5 (0.362± 0.006mg/kg) Nickel concentration in LS was (23.980 ± 0007mg/kg) while other samples had no detectable concentration.

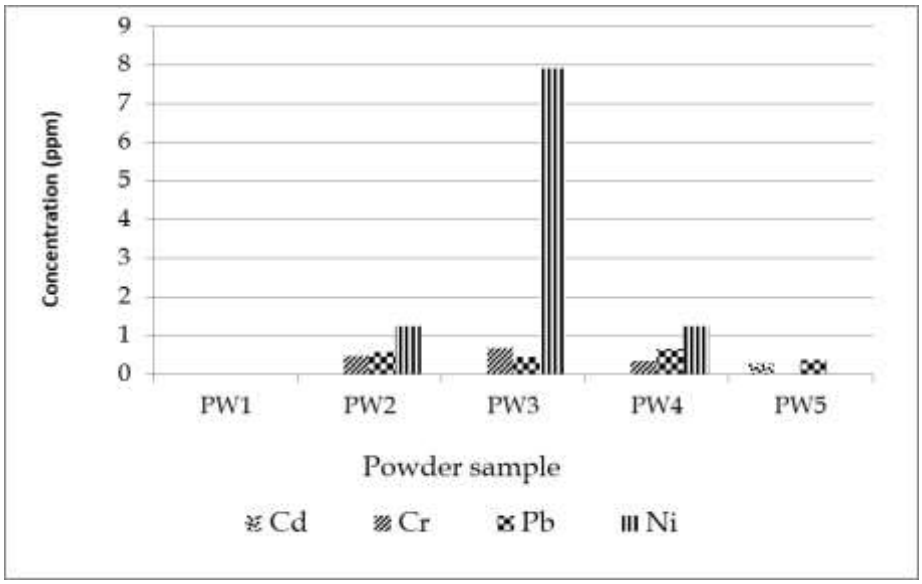

Figure 9: Heavy metal concentration in powder samples

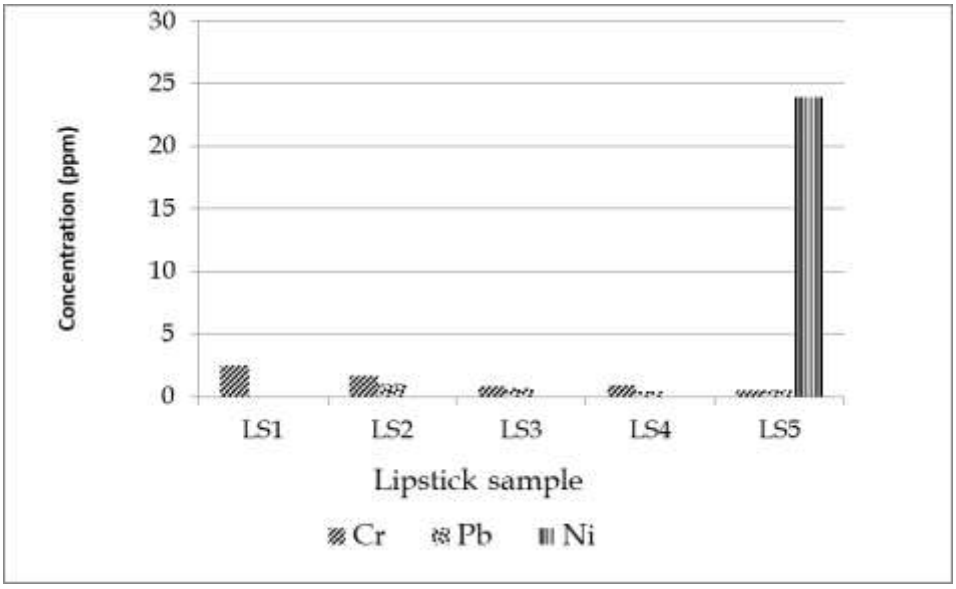

Figure 10: Heavy metal concentration in lipstick samples

Chromium was also detected in all the eye shadows (ES) evaluated. The highest concentration obtained was n ES 5 (3.55 ± 0.181 Mg/kg) while the lowest was in ES 6 (0.273 ± 0.067 mg/kg). Nickel was not detected in ES 2 but among the other samples, highest concentration was in ES1 (13.150±0.006 mg/kg) with the lowest in ES 2 (0.150 ± 0.000).

Likewise, in all the eye shadow samples analysed, Pb was detected in ES 1, ES 2, ES 3, ES 4 and ES 5 with highest concentration obtained in ES 1 (1.025 ± 0.000 mg/kg) while the lowest was obtained n ES 4 (0.152 ± 0.000).

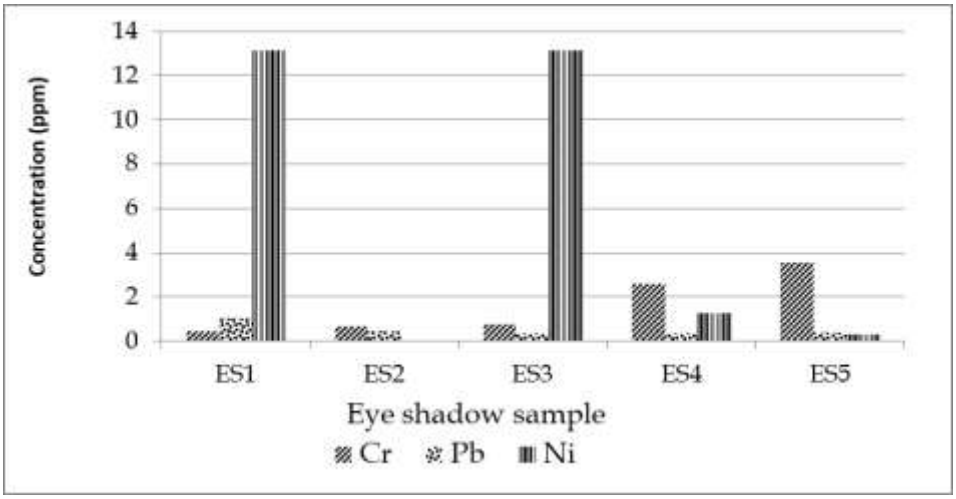

Figure 11: Heavy metal concentration in eye shadow samples

Similarly, in eyeliner (EL), Cr, Ni and Pb were detected in all the brands evaluated. The highest value of Cr was obtained in EL 1 (0.887 ± 0.004 mg/kg) and lowest was in EL 5 (0.355 ± 0.005 mg/kg) while EL5 had the highest nickel (5.104 ± 0.0036 mg/kg) and EL1 had the lowest (1.051 ± 0.0045 mg/kg), whereas Pb was detected in EL 1, EL2, EL 3, EL 4 and EL5 with highest concentration obtained in EL2 (2.050 ± 0.004 mg/kg) while the lowest was in EL 1 (0.455 ± 0.002mg/kg).

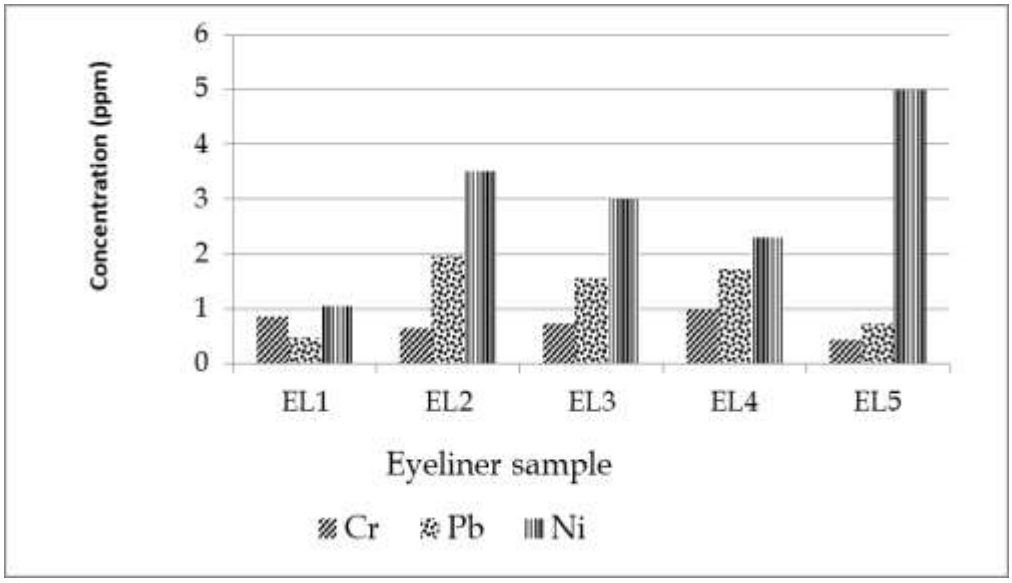

Figure 12: Heavy metal concentration in eyeliner samples

Overall, in terms of heavy metal content in the various makeup cosmetics categories, it was observed that ES, EL and LS had the highest Cr, Pb and Ni respectively while the order of relevance of the heavy metals was Ni>Pb>Cr>Cd. In this present study, nickel was found to be the highest detectable metal with highest value in lipstick (LS5) 23.980 mg/kg, followed by 13.150 mg/kg obtained in eye shadow (ES1) and 7.915mg/kg in powder (PW3). Chromium was also detected in all categories of the makeup products with eye and lip products having higher concentrations compared to powder and foundation samples.

DISCUSSION

Cosmetic makeup has become essential daily supplies of our present generation. They have been used significantly in the beauty industry to enhance outlooks, conceal blemish scars, skin discoloration etc. and in some cases protect and nourish the skin. However, these products may contain additives and impurities which may have toxic effect to human health and as such have been under restrictions by regulatory agencies (Gondal *et al*., 2010; Health Canada, 2017). This study is hitherto the pioneer study to our knowledge that evaluated the heavy metal contents of facial cosmetics products in Asaba, southern Nigeria.

In the current study, cadmium which was found in only one brand of powder sample (PW5) was below permissible limit when compared to standard of 5 mg/kg by Health Canada (2017) but above 0.1 mg/kg standard of German cadmium permissible limit (Gesundheitlicher and Wirtschaftlicher, 2010; Orisakwe and Otaraku, 2013). The observation of cadmium in only one sample of all the investigated cosmetics products suggests that cadmium is rarely observed in cosmetics and usually in concentration below permissible limit (Ullah *et al*., 2013; Siti *et al*., 2015; FDA, 2017). However, Cadmium has been reported to affect the female ovarian and reproductive tract morphology even at extremely low doses (Henson and Chedrese, 2004). Ingestion of cadmium during pregnancy has been linked with decreased birth weights and premature birth (Henson and Chedrese, 2004).

The levels of chromium detected in this study were comparable to other evaluations carried out with cosmetics products sold in Nigerian market (Iwegbuea *et al*., 2016; Sani *et al*., 2016). The observed eye and lip products having higher concentrations of Cr compared to powder samples in this research corroborate the detection of Cr (0.774 mg/kg) in higher concentration in Lipstick samples sold in Pakistan (Ullah *et al*., 2013). This also implies that the total estimated intake of Cr from the use of eye and lip products and the potential for additional exposure from other sources should warrant the need for additional research to establish Cr regulatory limit especially since no permissible limit for Cr in cosmetics has been established (Hwang *et al*., 2009; FDA, 2017).

The toxic effect of chromium compounds relies on the oxidation state of the metal; the hexavalent state of chromium is more toxic than trivalent, and it is recognized as a human carcinogen (to cause cancer) when inhaled (Iwegbuea *et al*., 2016; FDA, 2017). Other health effects connected with hexavalent chromium exposure include destruction of the small capillaries in kidneys and intestines, skin irritation or ulceration, oxidative damage, genetic aberrations, eye irritation, discoloration of teeth, edema and allergic contact dermatitis (Baruthio, 1992; Saeed *et al*., 2011; Theresa *et al*., 2013; Kimura, 2017)

Nickel is the most popular cause of contact allergy of all skin sensitizers, and it is also a major cause of hand eczema. Nickel Sensitization is normally caused by constant and prolonged skin contact with nickel ions releasing items (Nielsen *et al*., 2002; Bocca *et al*., 2007). It has been recorded that approximately 15–20% of women and 2–5% of men are allergic to nickel. A value for nickel lower than 5 mg/kg has been suggested as "good manufacturing practice," while the "target" amount to minimize the risk of sensitization in particularly sensitive subjects is suggested to be as low as 1 mg/kg (Basketter *et al*., 2003) However, allergy to nickel could cause severe contact dermatitis (Sainio *et al*., 2000; Health Canada, 2017b). The detection of nickel in this present study agrees with previous research regarding cosmetics (Gondal *et al*., 2010; Orisakwe and Otaraku, 2013; Siti *et al*., 2015). However, LS 5 (a lipstick sample) with the highest nickel concentration of 23.890 mg/kg does not correlate with previous finding where detectable level of Ni was not observed in lipstick samples but in powder and eye make-up used in Nigeria (Orisakwe and Otaraku, 2013), although Ni was observed in body creams, lip glosses and lip sticks in another study carried out in Nigeria (Adepoju-Bello *et al*., 2012). The permissible limit of nickel exposure has been suggested to be 5 mg/kg (Gonda *et al*., 2010) and 1 ppm (Gesundhetlicher and Wirtschaftcher, 2010), generally low limit of 1 mg/kg but should not exceed 5 mg/kg (Basketter *et al*., 2003). Therefore, PW 3, PW 6, LS 5, FD 2, ES 1 and ES 3 did not conform to these limits. Nickel has been banned in cosmetics by European law 76/768/EEC but is considered in minute concentration as impurities if it is technically required, thus, the amount of nickel that can be called impurity is yet to be established (Orisakwe and Otaraku, 2013).

Multiple standards have been suggested by several research and regulatory bodies in some countries to ensure a safe limit is established for lead exposure (Orisakwe and Otaraku, 2013). Based on sub-acute dermal toxicity study on albino rats, it was proposed that the maximum allowable concentration of Pb should be ≈10 mg/kg (Tsankov *et al*., 1982). Another study reported that the maximum Pb level should not be more than 10 mg/kg (Health Canada, 2017). Thus, comparing this permissible level with the values obtained in this study, which ranged from 0.302 ± 0.000 to 1.950 ± 0.004 mg/kg, the facial makeup products evaluated could be regarded as relatively safe for the users. However, the concentration of Pb in this study with the standard of 1 mg/kg established by German government, five products which are eye shadow (ES1), eyeliner (EL2, EL3 and EL4), and lipstick (LS2) were above limit. Coloured cosmetics such as lipstick, eye shadow and eyeliner are suggested to have high lead content (Sprinkle, 1995; Al-Saleh *et al*., 2009; Ullah *et al*., 2012) In addition, the use of cosmetics such as lipstick or eye shadows contaminated with lead, especially by pregnant or/and lactating women could lead to foetus and infants lead poisoning (Bellinger, 2008). In addition, lead has been implicated in diagnosis of several oxidative stress induced diseases irrespective of concentration over a period of time. Exposure to low amount of lead could cause aberration such as behavioural abnormalities, decreased learning and hearing and can also cause distortion of central nervous system, reproductive system, hepatic and renal systems, hematopoiesis and anaemia (Nourmoradi *et al*., 2013). Therefore, reports have suggested that there is no safe level of lead exposure (Bellinger, 2008), although the agency of Toxic Substances and Disease Registry (ATSDR) suggests that not much of Pb can be absorbed through the skin (ATSDR, 2007) but Pb poisoning in relation to cosmetics use has been recorded (Chauhan *et al*., 2010; Nourmoradi *et al*., 2013).

The relatively high level of some heavy metal in cosmetics makeup in Asaba may be due to the lack of effective regulation and enforcement of safety standards in the cosmetic industry. Many cosmetic products are imported from countries with poor safety regulations standard, and the Nigerian

government has limited resources to monitor and regulate the industry (Nigeria Nursing World, 2013). Additionally, many consumers are unaware of the potential health risks associated with heavy metal contamination in cosmetics, even the ones that are aware may choose to overlook it and regard it as mere scientific propaganda because of their limited knowledge of the toxicity of heavy metals and as such they may not take appropriate precautions to protect themselves.

CONCLUSION AND POLICY RECOMMENDATIONS

The findings from this study indicate that some facial cosmetics used in Asaba, Nigeria, contain heavy metals. Prolonged exposure to these toxic compounds could lead to the absorption of heavy metal ions through the skin, potentially causing significant health hazards such as skin cancer and other oxidative-related disorders. The cumulative effects of exposure over time are challenging to quantify, as the variety of cosmetic product combinations is vast, and consumers often use multiple products from different brands. This variability makes it difficult to assess the true impact of exposure. Therefore, it is crucial to implement ongoing public awareness campaigns that educate consumers about the risks associated with heavy metals in cosmetics. Additionally, the cosmetic industry must adhere to strict good manufacturing practices to ensure product safety. A critical step in safeguarding public health is the establishment of legal limits for heavy metals in cosmetic products in Nigeria. Furthermore, it is recommended that regulatory agencies be set up across various geopolitical zones to enforce these standards, with regular inspections and penalties for non-compliance. Strengthening collaboration between government bodies, industry stakeholders, and consumer advocacy groups will also be essential to create a safer cosmetic market and protect public health.

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CONFLICT OF INTEREST

The authors declare no conflict of interest

REFERENCES

Adepoju-Bello, A., Oguntibeju, O., Adebishi, A., Okpala, N., and Coker, H. (2012). Evaluation of the concentration of toxic metals in cosmetic products in Nigeria. *African Journal of Biotechnology*, 11(97), 16360-16364

Agency of Toxic Substances and Disease Registry. (2015). Toxicological Profile for Cadmium and Lead. https://www.atsdr.cdc.gov/toxprofiles/tp

Al-Ashbanab, R. M., Aslam, M. and Shah, A.H. (2004). A Toxic traditional eye cosmetic study in Saudi Arabia. *Pub. Health*, 6(118), 292–298.

Alsaffar, N. M. and Hussein, H. J. (2014). Determination of heavy metals in some cosmetics available in locally markets. *J. Environ. Sci. Toxicol. Food Technol*, 3(8), 9-12.

Al-Saleh, I., Al-Enazi, S. and Shinwari, N. (2009).Assessment of lead in cosmetic products. *Reg. Toxicol. Pharmacol*, 4(54), 105–113.

Amasa, W., Santiago, D., Mekonen, S. and Ambelu, A. (2012). Are cosmetics used in developing countries safe? Use and dermal irritation of body products in Jimma Town, Southwestern Ethiopia. *J. Toxicol*. 2(11), 1-8.

Ayenimo, J. G., Yusuf, A. M., Adekunle, A. S. and Makinde, O. W. (2010). Heavy metal exposure from personal care products. *Bull. Environ. Cont. Toxicol*. 7(84), 8-14.

Baruthio, F (1992). Toxic effects of chromium and its compounds. *Biol. Trace Elem. Res*, 11(32), 145-53.

Basketter, D. A., Angelini, G., Ingber, A., Kern, P. S. and Menne, T. (2003). Nickel, chromium and cobalt in consumer products: revisiting safe levels in the new millennium. *Contact Dermatitis*. 6(49), 1-7.

Bellinger, D. C. (2008). Very low lead exposures and children's neurodevelopment. Curr. *Opin. Pediatr*, 8(20), 172-177.

Borowska. S. and Brzóska, M. M. (2015). Metals in cosmetics: Implications for human health. *J. Appl. Toxicol.* 2(35), 51-72.

Chambers E.S., Vukmanovic-Stejic M. (2020). Skin Barrier Immunity and Ageing. *Immunology*. 4(160), 116 –125. Doi: 10.1111/imm.13152

Chauhan, A. S., Bhadauria, R.,Singh, A. K., Lodhi, S. S., Chaturvedi, D. K. and Tomar, V. S. (2010) Determination of Lead and cadmium in cosmetic products. *J. Chem. Pharm. Res,* 1(2), 92-97.

European Parliament and of the Council. (2009, November 30). Cosmetic Products (Text with EEA Relevance). https://eur-lex.europa.eu/eli/reg/2009/1223/oj

FDA's Testing of Cosmetics for Arsenic, Cadmium, Chromium, Cobalt, Lead, Mercury, and Nickel Content. (2022). Available_online:https://www.fda.gov/Cosmetics/ProductsIngredients/PotentialContaminants/ucm452836.htm

Gesundheitlicher und Wirtschaftlicher Verbraucherschutz. (2010). Federal Office for Consumer Protection and Food Safety, Germany press.

Gondal, M. A., Seddigi, Z. S., Nasr, M. M. and Gondal, B. (2010). Spectroscopic detection of health hazardous contaminants in lipstick using laser induced breakdown Spectroscopy. *J. Hazard Mater*. 175, 726-732.

Gunduz, S. and Akman, S. (2012). Investigation of lead contents in lipsticks by solid sampling high resolution

continuum source electrothermal atomic absorption Spectrometry. *Regul. Toxicol. Pharm.* 3(65), 34–36.

Hall, A. (2002). Heavy Chronic arsenic poisoning. *Toxicol*. Lett, 14(128), 69–72.

Hardy, A., Walton, R. And Vaishnav, R. (2004). Composition of eye cosmetics (kohls) used in Cairo. *Inter. J. Environ. Health Res*, 2(14), 83-91.

Henson, M. C. and Chedrese, P. J. (2004). Endocrine disruption by cadmium, a common environmental toxicant with paradoxical effects on reproduction. *Exp. Biol. Med. (Maywood),* 13(229), 383-392.

Hwang, M., Yoon, E. K., Kim, J. Y., Son, B. K., Yang, S. J., Yun, M. O., Choi, S.S., Jang, D. D. and Yoo, T. M. (2009). Safety assessment of chromium by exposure from cosmetic products. *Arch. Pharm. Res*. 32, 235-41.

International Agency for Research on Cancer (IARC) (2002). Monographs on the evaluation of carcinogenic risks to humans: some traditional herbal medicines, some mycotoxins, naphthalene and styrene. https://monographs.iarc.fr/ENG/Monographs/vol82/mono82.pdf

Iwegbue, C. M., Bassey, F. I., Obi, G., Tesi, G. O. and Martincigh, B. S. (2016). Concentrations and exposure risks of some metals in facial cosmetics in Nigeria. *Toxicol. Reports*, 1(3), 464-472.

Kimura, T. (2017). Metal-mediated epigenetic regulation of gene expression. *Yakugaku Zasshi*. 137, 273-279.

Lerner, A. (2019). Cosmetic Toxicology: A Review of the Literature. *Journal of Clinical and Aesthetic Dermatology*, 12(10), 14–23.

Lopaciuk, A. and Loboda, M. (2013, June, 21). Global beauty industry trends in the 21st century. Management, knowledge and learning. International Conference, Zadar, Croatia. http://www.toknowpress.net/ISBN/978-961-6914-02-4/papers/ML13-365.pdf

Magnano G.C., Rui F., and Larese Filon F. (2021). Skin Decontamination Procedures against Potential Hazards Substances Exposure. *Chem. Biol. Interact*. 17(344), 109-481.

National Agency for Food and Drug Administration and Control. (2020). Guidelines for the Regulation of Cosmetics in Nigeria.

Omoyajowo, K. O., Ogunyebi, A. L., Adenekan, O. A., Bakare, T. I., Omoyajowo, B. O., Odipe, O. E., and Samuel, I. A. (2021). Awareness of toxicological impact and risk of using talcum powder as a factor for ovarian cancer among women in three metropolitan cities of southwestern states, Nigeria. Journal of Applied Sciences and Environmental Management, 25(7), 1191–1199.

Omoyajowo, K. O., Raimi, M. O., Omoyajowo, K. A., Makengo, M. B., Adegboyo, S., Innocent, D. C., Oni, S., Oguntuyi, J., Oyediran, A., Ogunyebi, A. L., and Kakwi, D. (2024). Towards a reduced pollution society: Systematic review on the role of storytelling, social media, humor and celebrities' influence for research communication. *Journal of Applied Sciences and Environmental Management*, 28(2), 603 623.

Orisakwe,O.E. and Otaraku, J.O. (2013). Metal concentrations in cosmetics commonly used in Nigeria. *Sci.W. J.* 1(7), 123-125.

Popoola, O.E., Bisi-johnson, M.A., Abiodun, A and Ibeh, O.S. (2013). Heavy metal content and antimicrobial activities of some naturally occurring facial cosmetics in Nigeria. *Ife J. Sci.* 2(15), 637–644.

Sabah, E. A. E., Hassan, M. A. and Almoeiz, Y. H. (2013). The hazards of hidden heavy metals in face make-ups. *Bri. J. Pharmacol. Toxicol*. 2(4), 188-193.

Sahu, R., Saxena, P. and Johnson, S. (2004). Heavy metals in cosmetics. Centre Sci. Environ, 1(1), 1-28. Available online: http://www.cseindia.org/userfiles/Heavy_Metals_in_Cosmetics_

Sani, A., Gaya, M. B. and Abubakar, F. A. (2016). Determination of some heavy metals in selected cosmetic products sold in Kano metropolis, Nigeria. *Toxicol. Report*. 2(3), 866-869.

Souiden, N. and Diagne, M. (2009). Canadian and French men's consumption of cosmetics: a comparison of their attitudes and motivations. *J. Consum. Marketing*, 5(26), 97-109.

Sprinkle, R.V. (1995). Leaded eye cosmetics: a cultural cause of elevated lead levels in children. *J. Fam. Practice*, 40, 358–362.

Theresa, O. C., Onebunne, O. C., Dorcas, W. A., and Ajani, O. I. (2013). Potentially toxic metals exposure from body creams sold in Lagos, Nigeria. *Researcher*, 1(2), 30–37.

Theresa, O. C., Onebunne, O. C., Dorcas, W. A. and Ajani, O. I. (2011). Potentially toxic metals exposure from body creams sold in Lagos, Nigeria. *Res*, 3, 30-37.

Tsankov, I. U., Iordanova, I., Lolova, D., Uzunova, S. and Dinoeva, S. (2022). Evaluation of the content of heavy metals (lead and copper) in cosmetic. *Probl.Khig*, 3(7), 127-136.

Ullah, H., Noreen, S., Fozia, S., Rehman, A., Waseem, A., Zubair, S., Adnan, M. and Ahmad, I. (2013). Comparative study of heavy metals content in cosmetic products of different countries marketed in Khyber Pakhtunkhwa, Pakistan. *Ara. J. Chem*, 2(10), 10-18.

Valko, M., Morris, H. and Cronin, M. T. (2005). Metals, toxicity and oxidative stress. *Curr. Med. Chem.* 2(12), 1161–1208.

Velma, V., Vutukuru, S. S. and Tchounwou, P. B. (2009). Ecotoxicology of hexavalent chromium in freshwater fish: a critical review. *Rev. Environ. Health*, 3(24), 129-145.

Wanjari, N. and Waghmare, J. A. (2015). Review on latest trend of cosmetics-cosmeceuticals. *Inter. J. Pharm. Res. Rev*, 1(4), 45-51.

World Health Organization. (2018). Exposure to Heavy Metals: A Major Public Health Concern.

Yebpella, G. G., Magomya, A. M., Lawal, U., Gauje, B. and Oko, O. J. (2014). Assessment of trace metals in imported cosmetics marketed in Nigeria. *J. Nat Sci. Res*, 1(4), 14-15.

Yosipovitch G., Misery L., Proksch E., Metz M., Ständer S. and Schmelz M. (2019). Skin Barrier Damage and Itch: Review of Mechanisms, Topical Management and Future Directions. *Acta Derm. Venereol.* 7(99), 1201–1209. Doi: 10.2340/00015555-3296