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Assessment of heavy metals in unbranded nail polishes retailed in Karachi, Pakistan

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Abstract
This assessment determines the concentrations of arsenic, lead, chromium, nickel, and cadmium in 60 unbranded nail polishes of various colours that were available in local marketplaces in Karachi, Pakistan. The findings demonstrated that mean lead, arsenic, and chromium contents in all the samples fell below FDA-acceptable ranges, and no nail polish colour was discovered to contain levels of these metals that exceeded the upper limits. Similarly, the FDA standards were exceeded by 41.6% of the pink and 25% of the orange nail polish samples. In this investigation, > 3 μg/g Cd was found in nail polish samples of the colours red and pink, respectively, at 66.67% and 8.33%. The order of the mean As, Pb, Cr, Ni, and Cd concentrations in the samples of nail polish that were examined in this study was red>orange>brown>blue>pink; orange>red>blue>pink>brown; red>blue>brown>pink>red; pink>orange>red>blue>brown; and red>pink>orange>brown>blue. The pink and blue colour samples showed the highest levels of Ni (12.08 μg /g) and Cd (6.28 μg /g).

Keywords
Heavy metals, Nail Polish, Health, Karachi, unbranded

Introduction

Since the inception of civilization, women have been beautifying their nails with a nail polish, a sort of lacquer cosmetic product. Due to increased media attention given to beauty products (Gondal et al., 2010, Ullah et al., 2013), as well as rising public awareness of the need to maintain physical beauty, there has been a marked increase in demand for cosmetics recently. Cosmetics are those products that are used worldwide by men as well as women, and their suitability as a means of embellishment, personal hygiene, and beauty care can never be denied (Munir et al., 2020). Nowa-days, the most common cosmetics and beauty-care products are nail polishes, Lipsticks, eyeliners, mascara, tints, blush, highlighters, sunscreens, and. whitening creams (Dinake et al., 2023). Cosmetics are the obvious sources by which, especially women, are exposed to naturally existing heavy metals. Some metals are deliberately added to cosmetic products as ingredients. Examples include the lead acetate in advanced hair dye, ingredients of inorganic mercury in skin-brightening products (Ababneh et al., 2013). Most of the countries forbid the deliberate use of certain metals (Pb, Cd, Hg, Cr, and Ni) and their derivatives as active components in cosmetic products since they are deemed dangerous due to their toxicological profiles. However, because to their persistence and prevalence, these compounds can still be detected in cosmetic goods (Iwegbue et al., 2015; Bocca et al., 2014). A trace of naturally occurring heavy metals may be recognized as impurities in most cosmetics and beauty-care products (Marinovich et al.,.

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2014). The risk to human health from pollutants depends on their concentration in the body. In the past few years, attention has been drawn to cosmetics, cleaning supplies, and self-care beauty products as the main sources of heavy metals in humans without awareness of heavy metals in nail polishes (Ayenimo et al., 2006; Ayenimo et al., 2010). Nail polishes could be one of the causes of heavy metals to which women are exposed on a daily basis to enhance the beauty of their nails. The nail absorbs the pigments of the nail polish and vaporizes them, and soluble metals can easily pass through it (Munir et al., 2020; Karimi and Ziarati, 2015). Nails of humans are composed of 10–30% water and are more permeable than skin; the heavy metals in nail polish can get through the porous keratinized nail (Ouremi and Ayodele, 2014). These cosmetic products may contain multiple raw materials and pigments, including lead (Pb), arsenic (As), chromium (Cr), nickel (Ni), and cadmium (Cd), as these metals are durable and occur naturally in rock, water, and soil (Bocca et al., 2014). A lot of bath and body cosmetics products are linked to multiple disorders and diseases, such as neonatal disease (Bocca et al., 2014; Ouremi and Ayodele, 2014). A large body of data indicates that arsenic (As), Cadmium (Cd), and Lead (Pb) can enter the foetus, in whole or in part, through the placental barrier, where they can affect foetal growth and health. Even low levels of exposure can be harmful and cause developmental and reproductive harm (Ouremi and Ayodele, 2014; Ullah et al., 2017). In the past, there have been numerous studies to determine the levels of metals in various cosmetic products (Chauhan et al., 2010). Only a few studies (Grosser et al., 2011; Kulwa & Mihale, 2020) have published the concentrations of metal in nail products. The study of Bocca et al. (2014) provided evidence in support of this study.

Material and Methods

Sampling

During the study, 60 samples of unbranded nail polish were purchased in five different shades from twelve diverse local markets of Karachi i.e. (i) Resham Galli (Shah Faisal Colony # 1) (ii) Tuesday Bazaar (Shah Faisal Colony # 1) (iii) Korangi # 5 (Iv) Quaidabad (v) Landhi (vi) Malir (vii) Memon Goth (viii) Shah Lateef Town (ix) Orangi Town (x) Sunday bazar; Gulistan-e-Johar (xi) Mosamiyat (University Road) (xii) Bolten Market respectively. These markets feature unlicensed small businesses where little attention is paid to quality control selling locally made cosmetic products. Because of this, most customers are ignorant of how applying such cosmetic goods might expose them to numerous dangerous heavy metals. Blue, Brown, Orange, Pink, and Red are the five most frequently utilised colours. In this regard, all samples were appropriately labelled with sample codes and subsequently stored for laboratory analysis at room temperature.

Sample digestion and heavy metal analysis

The methods for sample digestion have already been documented (Iwegbue et al., 2015; Iwegbue et al., 2016). Briefly, 20 mL of concentrated nitric acid, 10 mL of perchloric acid, and 5 mL of hydrogen peroxide were added to 1.0 g of each sample in a Teflon jar. The mixture was then covered and left to stand for the night. The sample was heated to 125 °C for two hours the next day on a controlled hotplate. The sample solution was allowed to cool before the digesting tube's lid and side walls were rinsed with 0.25 mol/L HNO_3, filtered, and diluted to 25 mL with the same solution. Using Merck Super Nova 60 kits, the heavy metals (As, Cr, Cd, Pb and Ni) were examined in all of the digested nail polish samples. The experiment was conducted three times for each sample, and the results were then calculated as mean values and standard error.

Results and Discussion

Nail polishes have significantly evolved in recent years, containing heavy metals and other irritants, making them an important concern in the nail care and manicure industry (Ceballos et al., 2021; Fan et al., 2022). This study examined the levels of five selected heavy metals (Pb, As, Cr, Ni, and Cd) in different shades of nail polish purchased from the local shops and markets of Karachi, Pakistan. A person can be exposed to heavy metals through skin contact and inhalation during the application of nail polishes, as well as by chewing or biting nails, leading to the ingestion of nail polishes (Narloch et al., 2021). The colours used in nail polishes are a determining factor of metal contamination; for instance, arsenic and nickel are considered impurities in colour additives since they've not been found as common ingredients in nail polishes (Karimi and Ziarati, 2015). Table 1 represents the minimum, maximum, and mean concentrations of heavy metals found in different colours of nail polish compared to the international acceptable limits set by the WHO and FDA, highlighting the possible health hazards due to its prolonged use.

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Table 1. *Concentration of toxic metals in different colors of unbranded nail polish*

Sample color	HEAVY METALS				
	As	Cd	Cr	Ni	Pb
	Mean ± SD values (µg/g)				
BLUE	0.093 ±0.029	0.286 ±0.254	0.487 ±0.249	1.640 ±0.831	2.854 ±1.610
BROWN	0.128 ±0.111	0.397 ±0.132	0.467 ±0.145	1.614 ±0.4001	2.067 ±0.848
ORANGE	0.141 ±0.088	1.054 ±0.572	0.272 ±0.240	3.257 ±1.526	3.663 ±1.579
PINK	0.015 ±0.017	1.551 ±0.795	0.288 ±0.149	5.278 ±2.476	2.535 ±0.910
RED	0.244 ±0.113	3.968 ±1.508	0.839 ±0.352	2.303 ±0.998	3.386 ±1.176
FDA Limits	3.0	3.0	5.0	5.0	20

Arsenic. From Table 1, the mean As concentrations in nail polish samples were found in the order of red>orange>brown>blue>pink, with the highest concentration (0.48 µg/g) observed in the brown colour sample purchased from Resham galli (Shah Faisal colony # 1) and the lowest concentration (0.001 µg/g) in the pink colour purchased from Mosamiyat (University Road). During this study, all the nail polish samples were found within the permissible limit of 3.0 ppm as set by the FDA. These outcomes match with the outcomes of unbranded whitening cream sold in Karachi (Alamgir et al.,2022). Similarly, a study conducted by Jihad (2020) illustrated that the local cosmetic products of Iraq contained considerably elevated concentrations of arsenic, i.e., in the range of 4.83-5.73 ppm, as compared to the current research. Moreover, Mohammed et al. (2017) showed a significant concentration of arsenic in skin bleaching agents. Despite these findings, arsenic is one of the elements that are rarely present in cosmetics; however, its presence can be a concern if applied on a long-term basis (Borowska and Brzoska, 2015). Arsenic can be found in various products such as pigments, preservatives, and textiles (ATSDR, 2007), and being exposed to it can affect the heart, digestive tract, and central nervous system. It can also lead to cancer and bone disease (Jomova et al., 2011).

Cadmium. Cadmium is a toxic metal and has been found to be linked to diabetes and high blood pressure (Godt et al., 2006). Even low exposure to cadmium can prevent neurological development (Wang et al., 2016). An increase in cadmium levels has been reported to. inhibit DNA repair, including mismatches, base removal, and nucleotide removal (Chen et al., 2019). 3.0 µg/g is the limit set by Health Canada for Cd in cosmetics intended for external use (Health Canada, Santé Canada, 2012). About 66.67 % and 8.33 % of nail polish samples of red and pink colour were > 3 µg/g Cd in this study. The mean Cd concentrations in the investigated nail polish samples were found in the order of red>pink>orange>brown>blue. The highest Cd content (6.28 µg/g) was examined in blue, while the lowest Cd content (0.014 µg/g) was present in red, collected from Malir and Landhi towns markets. In comparison to this investigation, Grosser et al. (2011) reported lower cadmium amounts in nail color products. Cadmium concentrations that were lower. All bath and body products contained low levels of cadmium (Lavilla et al., 2009). Similarly, Lavilla et al. (2009) also reported trace amounts of cadmium in bath and body products.

Chromium. Chromium is a major source of allergic Allergic Contact Dermatitis (ACD) and skin ulcers (Hwang et al., 2009; Shelnutt et al., 2007). Chromium ACD can be a chronic, debilitating condition, perhaps because chromium is difficult to avoid (Theresa et al., 2011). During this study, the highest Cr concentration was found to be 1.371 µg/g (Mosamiyat, University Road) in the red colour of nail polish samples, whereas the lowest Cr concentration of 0.015 µg/g was obtained from Korangi #5 market in the orange shade of nail polish samples. The order of mean Cr concentration in all nail polish samples was red>blue>brown>pink>orange, respectively (Table 1).

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All Cr concentrations were well within the safe limits of the FDA. According to Corazza et al. (2009), children's nail polish had a Cr concentration of less than 1 μg/g. Grosser et al. (2011) examined six coloured nail polish samples from various brands and discovered that two of the samples contained 6.58 and 10.9 μg/g of Cr, whereas the other four samples had Cr values <3 μg/g. When nail polish is ingested, the Cr quantities found in all of the samples could be of concern. Comparatively, slightly higher Cr concentration was reported in unbranded whitening cream sold in Karachi city. According to Sahu et al. (2014), Cr levels in Indian lip balms, lipsticks and anti-ageing creams had Cr concentration upto 13.8 μg/g.

Nickel. According to Basketter et al. (2003), sensitized people only occasionally react to Ni concentrations below 10 μg/g in the existence of irritants and/or after frequent exposures. The maximum amount of nickel that can be contained in cosmetic goods is not regulated by national or international law. The authors suggested that, in order to provide even more protection, the ultimate target level for Ni content in cosmetic items should be set at 1 μg/g rather than 5 μg/g, as was previously suggested. In this study, 41.6 % nail polish samples of Pink colour and 25% orange colour nail polish were beyond the FDA guidelines. The mean concentrations of Ni in the analysed nail polish samples in this study were found in the order of pink>orange>red>blue>brown, with the highest concentration (12.08 μg/g) observed in the pink colour sample and the lowest concentration (0.405 μg/g) in the brown colour collected from Gulistan-e-Johar. These findings match with the findings of Corazza et al. (2009). But some cosmetic products have been reported to contain higher Ni concentrations than those in the current investigation (Ouremi et al., 2014; Contado and Pagnoni, 2012; Nnorom et al., 2005; Volpe et al., 2012; Sainio et al., 2000). Studies are also carried out in Pakistan to evaluate the presence of Ni in cosmetics (Alamgir et al., 2022; Munir et al., 2020; Ullah et al., 2017). According to Magaye et al. (2014), exposure to nickel compounds can result in hypersensitivity, nephrotoxicity, and skin irritation.

Lead. Lead is a highly toxic heavy metal and a common environmental pollutant that has been widely released into the environment for centuries (Brown and Margolis, 2012; Clausen et al., 2011). Exposure to higher levels of lead can lead to serious health problems like damage to the nervous system, kidneys, digestive system, and reproductive system, as well as increased blood pressure (Ullah et al., 2009). The US FDA (2013) set a 20 μg/g maximum limit for lead in color additives used as parts of cosmetic items. Health Canada uses a lower lead level (10 g/g) as its safe standard limits because it believes that this level is conservative and protecting of consumers, especially children (Health Canada-Sante' Canada, 2012).

The mean Pb content found in all samples of nail polish were in the order of orange>red>blue>pink>brown respectively (Table 1). Pb content were fluctuated from 0.93-6.41 μg/g in this study. Highest content was identified in an orange color nail polish purchased from Korangi # 5 market. All the samples were in a safe limit set by US FDA (2013) and Canadian safety threshold limit. These finding matches with the findings of Grosser et al. (2011) and Iwegbue et al. (2016) in nail polish sold in Nigeria. A similar study conducted by Ouremi and Ayodele (2014) in Nigeria showed much higher lead levels in nail polish samples as compared to the present study, greatly exceeding the permissible limit set by WHO. The same study also revealed that the colored nail polish samples have higher lead concentration whereas the level of lead was much lower in white color samples due to the absence of dyes. A comparable investigation that was carried out in Quetta to evaluate the presence of heavy metals, Lead concentrations were substantially lower in locally marketed cosmetic products than in the current investigation (Rasheed et al., 2023). According to Ullah et al. (2017) and Alamgir et al. (2022), high Pb concentrations were also discovered in unbranded whitening creams marketed in Karachi. This was confirmed by a second investigation conducted in KPK.

Conclusions

According to the study, the main cause of the increase levels of heavy metal contamination in the nail polish samples is improper manufacturing practices without adequate monitoring of hazardous metals throughout production. Techniques for quality control are not used. To prevent human exposure to such dangerous heavy metals, it is therefore necessary that the fate of heavy metals in cosmetics be monitored and regulated, particularly in unbranded items. Another significant issue that requires attention is the lack of clear safety regulations in the country for evaluating the presence of heavy metals in cosmetic items. Additionally, more research is required to determine the dangers of human

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exposure to various harmful heavy metals due to the regular application of cosmetics contaminated with heavy metals. It is also critically necessary to establish allowable limits for probable pollutants in cosmetic items, which must be implemented locally. Cosmetic items must be produced with safe manufacturing techniques in order to improve product quality without endangering consumer health, keeping in mind that heavy metals cannot be removed from such demanding products after they have been manufactured.

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