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Full Length Research Paper

Trace metal contents of facial (make-up) cosmetics commonly used in Nigeria

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Several facial cosmetics available in Nigeria were analyzed for their contents of the heavy metals; lead, cadmium, chromium, nickel, zinc and iron. The levels of chromium, iron and zinc were much higher in the samples than those of the non-essential toxic metals; lead, cadmium and nickel. The range of the geometric average for the various cosmetics is: Fe, 97-256 µg/g; Ni, 8-13 µg/g; Pb, 87-123 µg/g; and Zn, 88-101 µg/g. The geometric mean values obtained for Cr and Cd were generally below 40 µg/g and about 1 µg/g, respectively. Our result indicates that these cosmetics are relatively safer to use when compared to the lead-based kwali eye make-up commonly available in Nigeria. These data indicate that the continuous use of these cosmetics could result in an increase in the trace metal levels in the ocular system and the human body beyond acceptable limits. The application of these cosmetics needs to be considered as a source of lead in evaluating patients with symptoms of lead intoxication in regions where this practice is common.

Key words: Heavy metals, eye, cosmetics, make-up, lead.

INTRODUCTION

The potential lead exposure to the eyes as a result of the use of traditional cosmetic kohl in Asia, Africa and the Middle East has been a subject of debate to the scientific community (Worthing et al., 1995; Al-Hazza and Krahn, 1995; Lekouch et al., 2001; Smart and Madan, 1990; Hardy et al., 2004). Eye cosmetics such as kohl and surma have been identified as a suspected source of Pb exposure to the ocular system in a number of adults and children (Parry and Eaton, 1991; Sprinkle, 1995; Alkhawajah, 1992). The use of leaded eye cosmetics have been observed to be strongly correlated with elevated blood lead levels (Sprinkle, 1995; Bruyneel et al., 2002; Al-Ashban et al., 2004; Moghraby et al., 1989; Hearly et al., 1982; Ali et al., 1978)

The environmental and public health implications of exposures to lead in Africa have been reviewed and the use of local herbal remedies and cosmetics have been indicted as sources of lead exposure (Chukwuma 1997; Nriagu, 1992). A study of the use of skin lightening creams containing hydroquinone, corticosteroid and mercury in Nigeria revealed a prevalence of dermatological side effects with exogenous ochronosis as the commonest (Adebajo, 2002). Underarm cosmetics are being investigated as a possible cause of breast cancer. A biological basis for breast carcinogenesis could result from the ability of the various constituent chemicals to bind to DNA and to promote growth of the damaged cells (Darbre, 2003). Similarly, a study of cosmetic talcum and powder has shown that these products were rarely the pure mineral talc, but rather were mixtures of various minerals. Talcum powders have been observed to contain asbestiform and substantial concentrations of Ni, Co, and Cr (Rohl et al., 1976). Kohl and surma are

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composed of galena (PbO), amorphous carbon, zincite (ZnO), sassolite (H_3BO_3), minium (Pb_3O_4), magnetite (Fe_3O_4), goethite (FeO(OH)), cuprite (Cu_2O), and talc ($Mg_3Si_4O_{10}(OH)_2$) (Ali et al., 1978; Hardy et al., 1998, 2002; Worthing et al., 1995; Hearly et al., 1982).

There is a growing concern about the physiological and behavioral effects of environmental trace metals in human population. The toxicity of Pb at high levels of exposure is well known, but a major concern of today is the possibility that continual exposure to relatively low levels of lead may entail adverse health effects (Bergback et al., 1992; Koller et al., 2004). Lead and cadmium are two potentially harmful metals that have aroused considerable concern. In fact, lead has been described as the most severe environmental contaminant to arise in human civilization (Smith and Flegal, 1995). Lead is considered the most dangerous due to the extent that it is distributed in the environment as a polluting element. Lead impairs the renal, homopoietic and nervous system and reports of various surveys suggest that Pb is causally related to deficiency in cognitive functioning (Lansdown and Yule, 1986; Pocock et al., 1994; Chukwuma, 1997).

Besides lifestyle, living conditions and culture have tended to govern exposure to toxic metals including Pb (Nriagu, 1992; Chukwuma, 1997). Lead has been applied for its supposed magical or chthonic properties. Otanjere (Nigerian name in Igbo language) that contains up to 81% of lead is commonly scavenged from the Benue valley trough of which the abandoned Enyingba – Abakiliki lead and zinc mine is part, and applied in the treatment of ophthalmologic infections, as an eye cleanser and in cosmetics (Healy et al., 1984; Chukwuma, 1997). Similar studies of traditional eye make-ups used in Nigeria have reported very high levels of trace metals in locally sourced eye make-ups (Funtua and Oyewale, 1997; Ajayi et al., 2002). However there is paucity of data on the trace metal content of the processed cosmetics.

The very high levels of trace metals especially lead in the locally sourced eye make-ups necessitates a study of other imported and locally produced cosmetics used in Nigeria. The objective of the present study therefore is to examine further the trace metals content of facial cosmetics commonly used in Nigeria.

MATERIALS AND METHOD

Facial make-ups including eye pencils, eye liners and mascara; lipsticks and lips gloss; and native eye liners (tiro and uhie, names in Igbo language) were purchased from retail outlets and open market in Umuahia, southeast Nigeria. The samples were dried to constant weight in an oven at 80°C for 12 h. 1 g of the dried samples was digested with HNO_3, evaporated to near dryness on a hot plate and then cooled. The procedure was repeated with $HClO_4$. More $HClO_4$ was added until evolution of white fumes (marking the end of the digestion process) before heating to near dryness. The digest was taken up in 1 M HNO_3, filtered with Whatman No 4 filter paper into 10 cm^3 volumetric flask and made up to mark with deionized water. This was subsequently analyzed for Pb, Cd, Cr, Zn, Ni and Fe using an air-acetylene flame atomic absorption spectrophotometer (UNICAM, 969) by the standard calibration technique. Batch precision and accuracy were successfully monitored with a 10% insertion rate of sample duplicates, blanks and spikes. Appropriate quality assurance procedures and precaution were carried out to ensure reliability of the results. Results from each batch were accepted if control samples were within 10% of the accepted value of these samples.

RESULTS AND DISCUSSION

The distribution of trace metals in the facial cosmetics studied is shown in Table 1. Because of the positively skewed nature of the results, the geometric mean of the results was calculated as it is a better estimate of the average than the arithmetic mean. The range of Pb levels for lipsticks is wider than that for local eyeliners, while the geometric mean value for the local eye-liners (120.5 µg/g) is much higher than that for the lipsticks (87.3 µg/g). Comparative amounts of Pb were found in the local eye-liners and the eye pencils. Their arithmetic and geometric average are approximately the same 130 µg/g and 120 µg/g, respectively. This may indicate the use of similar materials (graphite) in these cosmetics.

The levels of Cd are generally low, being much less than 3 µg/g. Chromium levels on the other hand were much higher than the corresponding levels of nickel and cadmium in each sample group. Levels of the metals, Cr, Fe, and Zn were much higher in the samples than those of the non-essential metals, Pb, Ni and Cd. Zinc and Fe levels were the highest. Correlation study of the data indicated only a relatively weak correlation between Cr and Zn ($r = 0.5$) and between Cr and Cd ($r = 0.4$).

Iron and zinc are not of toxicological significance. Iron compounds have an established role as colorants in many cosmetic products. Evidence shows that in addition to its importance as an essential nutrient necessary for oxygen metabolism and mitochondrial function, Fe exhibits a functional importance as a trace metal in the normal growth and functional maturation of the skin (Landsdown, 2001). Thus the observed high values of these metals may not indicate any present possible health hazard. Similarly, the low values observed for Cd are within acceptable range. However the continuous use of these cosmetics may enhance the absorption of especially Cd and Pb during eating for lipsticks and during sweating for the other facial make-ups. Exposure to lead by dermal contact can contribute to significant toxicity (Moyer et al., 1999). The health implications of the use of these cosmetics can only be properly assessed by monitoring the levels of these toxic metals in the blood and urine samples of the group engaged in the practice.

It should be noted, however that these cosmetics are relatively safer to use when compared to the lead-based kwali eye make-ups which have been reported to contain

Table 1. Trace metal contents (Mean ± SD) of facial cosmetics (make-ups) available in Nigeria (µg/g, dry weight).

Metal	Eye Liners	Eye pencils	Lipstick
Fe	195.3 ± 111.9	133.0 ± 98.6	297.5 ± 167.6
	(169.2)*	(97.2)	(256.1)
	78.0 – 325.2**	17.0 – 288.3	92.2 – 632.0
Ni	9.2 ± 4.1	13.4 ± 5.8	14.6 ± 6.3
	(8.43)	(12.1)	(13.3)
	4.4 – 14.5	4.9 – 21.5	7.0 – 22.8
Pb	131.0 ± 61.0	129.2 ± 40.4	105.5 ± 67.5
	(120.5)	(123.2)	(87.3)
	66.4 – 213.6	66.0 – 187.1	28.7 – 252.4
Zn	94.4 ± 27.6	111.9 ± 49.6	94.9 ± 38.5
	(91.5)	(100.9)	(88.0)
	72.0 – 128.5	36.3 – 198.7	42.3 – 174.8
Cr	37.8 ± 4.1	41.5 ± 12.7	31.8 ± 11.2
	(37.6)	(39.9)	(30.4)
	33.5 – 43.1	25.8 – 64.3	20.5 – 58.8
Cd	1.3 ± 0.7	0.8 ± 0.2	1.1 ± 0.6
	(1.0)	(0.7)	(0.9)
	0.3 – 1.8	0.5 – 1.1	0.5 – 2.4

*Geometric mean.
**Range.

>60% lead (Funtua and Oyewale, 1997). The graphite-based kwali is also relatively safer, as lower values of Ni (14-30 µg/g), Zn (11-19 µg/g), and Pb (23-32 µg/g) were observed in them compared to the lead-based kwali. However, very high levels of Fe were reported in both the graphite-based kwali (>4300 µg/g) and the lead-based kwali (0.98 – 1.2%) which reflects the natural source of these materials (Funtua and Oyewale, 1997). High levels of Zn (35.8%) and Fe (6.15%) were also reported in ornamental lead which women use to adorn their eye lashes in Nigeria (Ajayi et al., 2002).Clinically, lead poisoning from use of lead-based eye cosmetics is presented with abdominal crampoid pain, encephalopathy (manifested as anxiety and irritability), and anemia (Bruyneel et al., 2002).

Apart from an extensive data available on Pb intoxication on CNS and the hemopoietic system, very little information is available regarding its effects on the ocular system (Dwivedi, 1996). Kohl and other local cosmetics worn around the eyes in Asia, Africa and the Middle East have been identified as suspected source of Pb exposure to the ocular system (Dwivedi, 1996; Parry and Eaton, 1991; Alkhawajah, 1992; Sprinkle, 1995). Data on elemental analysis of the ocular lenses exposed to Pb demonstrates that long-term low-level Pb exposure results in significant perturbations in the status of the essential trace metal ions such as Ca, Fe, Cu and Zn. The effect of Pb on the levels of these divalent metal ions could be the result of competition for common binding sites (Dwivedi, 1996). Lead is a biogeochemical analogue to calcium. As such it is readily incorporated into trophic and metabolic pathways (Smith and Flegal, 1995). Significantly higher levels of Cu, Pb and Cd have been observed in human lenses of people suffering from cataract. Ophthalmologists have indicated that a seemingly disproportionately high percentage of patients with intransigent glaucoma have elevated Cd levels. The use of eye cosmetics may be a major source of these metals in human lenses (Cekic, 1998).

A recurrent theme in research on childhood lead poisoning has been the discovery time and again over the past four decades that Pb is toxic to the developing nervous system at levels previously thought to be safe. The observation that these facial cosmetics are used on neonates and by pregnant women should elicit concerns. Studies have reported that breastfeeding enhances the release of lead from the bones (Tellez-Rojo et al., 2002) and that lead freely crosses the placenta (Shannon, 2003; Srivastava et al., 2001). Consequently, gestational Pb poisoning is not only harmful to the woman, but also to the developing fetus, invariably producing congenital lead poisoning. Epidemiological studies confirms an association between lead exposure and prevalence of dental carries in school-age children (Campbell et al., 2000; Gemmel et al., 2002; Omar et al., 2001). The applications of local preparations containing Pb in the treatment of ophthalmogic infections and as an eye cleanser and in cosmetic have been identified as a major source of Pb intake in Africa (Chukwuma, 1997).

The probable ill-effect from the use of lead ore for

Table 2. Levels of heavy metals in some facial cosmetics in some other parts of the world.

Country	Class/Name of cosmetics	Pb	Cd	Ni	Fe	Zn	Reference
Saudi Arabia	henna	1.29-16.48 µg/g	-	-	-	-	Al-Saleh-and Coate, 1995
Saudi Arabia, India,	kohl	2.9-100%	-	-	-	-	Al-Hazzaa and Krahn, 1995
Middle East	western eyeliner pencils	ND					
Morocco, US	kohl	0.6%-50%	-		46%		Parry and Eaton, 1991
Mauritania, Pakistan, India,Great Britain							
Saudi Arabia.							
Bulgaria	eye shadow, lipstick and powders	ND-41.1 µg/g	-		-		Tsankov et al.,1982
-	eye shadows	<20µg/g	-	1-49 µg/g	-	-	Sainio et al., 2000
Oman and UAE	bint al dhahab	~91%(PbO)	~0.05%	-	-	-	Worthing et al., 1995
Bahrain	suma and kohl	< 0.16%	-	-	-	-	Madany and Akhter, 1992
-	surma	~88%	-	-	-	-	Moghraby et al., 1989
-	kohl	~53%	-	-	-	-	Al-Ashban et al., 2004
Israel	Kohl	17.3-79.5%	-	-	-	-	Nir et al., 1992
Nigeria	galena based kwali	58.8-62.4%			0.98-1.2%		Funtua and Oyewale, 1997
	graphite-based kwali	23-32 µg/g	14-30 µg/g		0.43-0.46%		
Nigeria	local eye shadows	-	-	-	6.15%	35.8%	Ajayi et al., 2002

ND = Not detectable.

cosmetics and other purpose in mineralized areas such as the Benue valley/trough of Nigeria and several other developing countries have not been reported or documented (Chukwuma, 1997). Three folds blood lead levels have been observed in users of lead-based eye cosmetics compared to non-users in Pakistan, India and Saudi Arabia (Bruyneel et al., 2002; Sprinkle, 1995; Alkhawajah, 1992)

Studies of the effect of blood lead on children's mental development have shown intelligence quotient deficits of an estimated 0.25 points for every microgram per deciliter (µg/dL) increment in blood lead level (US CDC, 1991a; Needleman et al., 1979; Wang et al., 2002). It has been suggested that lead may have this effect by interfering with the role of calcium in brain cell development (Driscoll et al., 1992) and because the developing nervous system is thought to be far more vulnerable to toxic effect of lead than the mature brain (Koller et al., 2004). Unfortunately, it is not known whether treatment to reduce blood lead levels prevents or reduces such impairment (Rogan et al., 2001). On a societal basis, the aggregate loss on cognitive acuity due to lead exposure can be enormous. Acknowledging these impacts, the US Centers for Disease Control (CDC), the principal advisory agency for child health in the United States established a goal of reducing children's blood lead levels to below 10 µg/dL (US CDC, 1991b)

The use of lead based preparations such as cosmetics and local herbal remedies may account for very high level of up to 130 µgPb/L reported in the milk of nursing nomadic Fulani women in Northern Nigeria (Vander et al., 2001). These indigenous nomadics are semi-pastoralist and are not relatively exposed to automobile tailpipe which is a dominant source of airborne Pb in Nigeria and other developing countries that still use leaded gasoline (Awofolu, 2004; Nriagu et al., 1996; Thomas et al., 1999). Automobile exhausts were believed to account for more than 80% of the air pollution in Nigeria (Osibanjo and Ajayi, 1989). A baby exclusively fed with this milk is estimated to have an average Pb intake of 9.9 µg/kg/day,

a value twice the daily permissible intake (DPI) of 5.0 µg/kg/day set by WHO in 1972. This indicates that some exclusively breastfed Fulani infants may be at risk of injury from lead derived from their mothers milk. One can only but imagine the health implications and blood lead values of such infants considering that these cosmetics and herbal preparations are also used on infants and neonates.

The levels of heavy metals in similar cosmetic products in some other parts of the world are given in Table 2. Levels of Pb in unprocessed cosmetics kohl and surma are comparable to levels reported by Funtua and Oyewale (1997) in similar product (kwali) in Nigeria. Processed cosmetics available in Nigeria appear to contain higher levels of Pb compared to similar products available in Bulgaria, Saudi Arabia, India and the Middle East. However, the Fe levels of these products are higher than in Nigerian products. Levels of Ni comparable to levels found in Nigerian cosmetics were also reported by Sainio et al. (2000).

The present study indicate that the use of facial cosmetics exposes users to low levels of heavy metals of which Pb and Cd are of most toxicological concern. Understanding the consequences of low-level human Pb poisoning will depend upon an accurate assessment of the pervasiveness of toxicity in the global population. This will require that toxicity thresholds be determined as well as an understanding of the mechanisms underlying toxicity (Smith and Flegal, 1995). Education of parents and childcare workers regarding the risks of administering lead-based substances to children and themselves needs to be incorporated into health and healthcare framework systems in developing nations (Chukwuma, 1997).

In conclusions, this study has revealed that continuous use of these cosmetics could result in an increase in the trace metal levels in human body beyond acceptable limits. Efforts should be made at enlightening the users and the general public on the dangers involved.

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