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Essential Metal Levels in Cosmetologists, Heavy Cosmetic Users and Cosmetic-Naive Individuals in Benin City, South-South, Nigeria

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ABSTRACT

A growing number of research on the subject of cosmetics have been aimed at examining the toxicological and carcinogenic consequences of cosmetic use. This study aimed at evaluating the plasma levels of select biologically essential metals in cosmetologists, heavy cosmetic users, and in age-matched non-users of cosmetics (negative control group) in Benin City, Nigeria. From the blood samples obtained, levels of Iron, Zinc, Copper, Selenium, and Cobalt were determined using inductively coupled plasma mass spectrometry. Exposure frequency of ≥36h per week, coupled with inadequate use of personal protective equipment was observed among the cosmetologists. Though Selenium and Cobalt levels were significantly lower in cosmetologists, their levels were similar in non-users of cosmetics (NUC) and heavy cosmetic users (HCU). Levels of Zinc and Copper were similar in HCU and NCU but significantly higher when compared with cosmetologists. Iron levels varied significantly across the groups (NUC > HCU > cosmetologists). This study suggests that prolonged occupational and/or lifestyle exposure to cosmetic-borne chemicals may lead to a depression in the systemic levels of biologically essential metals such as Iron, Zinc, and Copper in cosmetic exposed individuals or users, and this may predispose to pathologic states associated with essential metal deficiency.

Keywords: Essential metals, Cosmetologists, Heavy cosmetic users, Non-users of cosmetics, Cosmetic-borne chemicals.

INTRODUCTION

A large chunk of scientific research on the subject of cosmetics have been aimed at examining the toxicological and carcinogenic consequences of cosmetic use. The most studied area of interest in cosmetic research is the identification of the ingredients used in the production of cosmetics, their safe limits, and potential toxicological risks. Several researchers have identified the ingredients frequently encountered in most beauty products and have gone on to suggest safe limits (Millikan, 2011). Cosmetics are products applied to the body for the purpose of beautifying, cleansing or improving appearance and enhancing attractive features (Singh, 2011). Common cosmetics include lipstick, powders, mascara, eye shadow, foundation, rouge, skin cleansers and skin lotions, shampoo, hair-styling products (gel, hair spray, etc.), perfume and cologne (Lewis, 2000; Poran, 2002 Schneider, 2005).

Following exposure from occupational, environmental and lifestyle sources, it has been reported that metals could accumulate in the body organs due to their long half-life (Orisakwe and Otaraku, 2013; Okereke *et al*., 2015; Price, 2015) and some of these metals may interfere with the metabolism of essential nutrients of similar oxidation states such as calcium and zinc (Adepoju-Bello et al., 2005) as well as other biological processes of the body (Sainio et al., 2000). Some cosmetics contain compounds such as lead, cadmium, beryllium, nickel, arsenic, mercury (Brokin et al., 2000), selenium, thalinum, chromium, paraben, diethanolamine, triethnolamine, poly(vinylpyrrolidone) copolymers, petrolatum, propylene glycol, stearalkonium chloride, biothionol, hexachlorophene, halogenated salicyl anilides, vinyl chloride, zirconium complexes, chloroform, methylene chloride, chlorofluorocarbon propellants, diazolidinyl urea, triazolidinyl urea, sodium lauryl (Al-davel et al., 2011), which have been shown to have harmful effects on human organs, resulting in conditions like photocontact sensitization, cancer, benign and malignant tumours of the lungs, contact dermatitis, potent allergen and skin irritation, skin granulomas, hepatocellular carcinomas, mental disorder, hyperpigmentation, violent cough, eczema, headaches, dizziness, rashes, reproductive dysfunction, endocrine disruption (Benard, 2004; Bernard, 2008a; Kapoor and Saraf, 2008).

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In spite of the profound interest in heavy metal hazards of cosmetics (Sainio et al., 2000; Lee et al., 2008; Abdel-fattah and Pingitore, 2009; Al-saleh et al., 2009; Ayenimo et al., 2009; Hepp et al., 2009; Borowska and Brzoska, 2015), very little attention has been given to metal contamination of cosmetic products in Nigeria and in most sub-Saharan African countries (Nnoron et al., 2007).

MATERIALS AND METHODS

Study area and participants

The study was conducted in Benin City, Nigeria. A total of hundred (100) female participants comprising fifty (50) occupationally exposed workers (cosmetologists); twenty (25) HCU and twenty-five (25) NUC were recruited from the University of Benin community. All the participants were apparently healthy and age-matched (with mean age of 25.4 years for cosmetologists; 23.7 years for HCU and 20.0 years for NUC.

Ethical consideration and informed consent

Ethical approval for this study was sought and obtained with reference number H.A 577/Vol/166 from the Ministry of Health, Edo State, Benin City. Informed consent was equally obtained from each participant to indicate voluntary participation in the study.

Inclusion and Exclusion Criteria

Use of alcohol and tobacco constituted exclusion criteria for the study. Only participants who were not experiencing their monthly menstrual flows were recruited for this study. It was ensured that all participants were apparently healthy, age- and sex-matched.

Sample Collection

Five (5) millitres of venous blood sample was collected aseptically from each participant and dispensed into anticoagulant-free specimen bottles to obtain serum for the essential metals (Zn, Cu, Se, Co and Fe) analyses. Serum was promptly aliquoted and stored at -80^{0}C until further analyses.

Determination of essential metal levels in blood

Micronutrient (Zn, Cu, Se, Co and Fe) levels in serum were determined in the analytical services laboratory of the International Institute for Tropical Agriculture, IITA, Ibadan, using the inductively coupled plasma mass spectrometer (ICP-MS) (Thermo Elemental, X series I, Germany), based on standard methods described by Fong et al., (2007).

Statistical Analysis

Data collected were analyzed using the Statistical Package for Social Sciences (SPSS) version 21.0 (IBM Inc., USA). The analysis of variance (ANOVA) used to compare means and results were expressed in mean ± standard error of the mean. A p-value of less than 0.05 ($p < 0.05$) was considered significant.

RESULTS

Table I shows the pattern of occupational exposure and risk awareness level among participants. A frequency of exposure of ≥ 36 h per week days per week among the cosmetologists was observed alongside inadequate use of personal protective equipment.

Table I. Pattern of Occupational Exposure and Risk Awareness Level amongst participants

Observations	Cosmetologists (n=50)	Heavy cosmetic Users (n=25)	Non-users of cosmetics (n=25)
Occupational Description	Hair Stylist=38% Nail care=8% Both=54%	Not applicable	Not applicable
Duration of occupational exposure	≥5.0years	Lifestyle Exposure	No occupational/ Lifestyle exposure
Frequency of exposure			Not Applicable
Route of exposure	≥6 days per week	Not applicable	Minimal exposure (Environmental)
Level of awareness of exposure risk	Hands, Dermal contact, nasal cavity, eyes, oral cavity, Environmental.	Dermal contact, nasal cavity, eyes, oral cavity, Environmental.	No response
	Yes=Basic awareness (n=3; 6%) No=No basic awareness (n=47; 94%)	No Response	
Personal protective devices	Frequent (n=2; 4%) Occasion (n=16; 32%) Non users (n=32; 64%)	Not applicable	Not applicable
Personal protective devices used	Gloves only (n=10; 55.5%) Gloves and apron (n=6; 33.3% Apron only (n=1;5.6%) Nose mask (n=1;5.6%)	Not applicable	Not applicable

Table II. Essential metal levels in cosmetologists, heavy cosmetic users and cosmetics naïve participants

Parameters	Cosmetologists (n=50)	Heavy cosmetic users (n=25)	Non-users of cosmetics (n=25)	F-value	P-value
Fe(µg/dL)	$81.97^{C}\pm1.19$	$120.48^{B}\pm1.04$	$129.44^{A}\pm1.79$	375.95	0.000
Zn(µg/dL)	$44.97^{B}\pm1.20$	$63.48^{A}\pm1.04$	$60.44^{A}\pm3.05$	36.53	0.000
Cu(µg/dL)	$89.21^{B}\pm1.27$	$114.15^{A}\pm1.74$	$116.2^{A}\pm1.03$	128.30	0.000
Se(µg/L)	$81.66^{A}\pm2.07$	$16.69^{B}\pm1.22$	$13.24^{B}\pm1.03$	450.37	0.000
Co(µg/L)	$0.32^{A}\pm0.01$	$0.15^{B}\pm0.01$	$0.16^{B}\pm0.01$	121.83	0.000

Note: Similar superscripts indicate mean that are not statistically significant from each other. Values are represented as Mean ± SEM

Also, Exposure to cosmetics-borne chemicals through almost all body cavities (skin, nose, eyes and mouth) was observed in both cosmetologists and heavy cosmetics users (HCU). Though Selenium and Cobalt levels were significantly lower in cosmetologists, their levels were similar in non-users of cosmetics (NUC) and heavy cosmetic users (HCU). Levels of Zinc and Copper were similar in HCU and NCU but significantly higher when compared with cosmetologists. Iron levels varied significantly across the groups (NUC > HCU > cosmetologists). Table II shows the levels of inorganic micronutrients (essential metals) in cosmetologists, HCU and NUC.

DISCUSSION

Until now, little attention has been paid to the possible effects of prolonged cosmetics use on micronutrients. Data obtained from this study showed that plasma Iron level was significantly lower in cosmetologists and HCU when compared with NUC. This finding suggests that prolonged cosmetic use may be a predisposing factor to iron deficiency anaemia and disordered erythropoiesis status in the participants exposed to cosmetic-borne chemicals (ASTDR, 1999; 2005). The significantly low plasma iron levels observed in cosmetologists and HCU relative to NUC suggests that cosmetics may contain certain elements that interfere with the absorption, transport and/or metabolism of iron. Moreover, evidence exist that suggest the involvement of lead toxicity arising from cosmetics absorption, inhalation and ingestion (Orisakwe and Otaraku, 2013) which is most likely implicated in the observed reduction in serum iron levels in the cosmetologists and HCU. Lead is a known inhibitor of the iron-dependent haem biosynthetic pathway by activation of key enzymes activities (ASTDR, 1999; 2005; Layer et al., 2010).

Blood Zinc (Zn) level was also significantly lower in cosmetologists compared to the other groups (CNP and HCU). In the same vein, blood Copper (Cu) level was also found to be significantly lower in the cosmetologists compared to HCU and NUC. Zn deficiency is of major concern in developing countries and has been associated with a number of pathologies (WHO-UNICEF, 2004; Muller and Krawinkel, 2005; FAO, 2014). Zn and Cu have significant antioxidant properties through the activities of superoxide dismutase (SOD), and these offer some form of protection to the body cells against oxidative stress and damage (Lobo et al., 2010). The Zinc deficiency observed in this study could be caused by toxic chemicals like formaldehyde (a constituent of some nail care products) and lead which is reportedly present in several cosmetics (Nnoron et al., 2007). Lead in turn has been shown to interact with zinc causing reduced serum levels of zinc (Pietal et al., 2003). Zinc deficiency may lead to disruption of zinc-dependent reaction and processes, affecting enzymes like Zinc/Copper SOD which is an antioxidant. SOD is necessary because superoxide reacts with sensitive and critical cellular targets to cause pathological condition, Reduced SOD activity is observed in oxidative damage (Heinrich et al, 2006). Zinc is required for normal nucleic acid, protein, and membrane metabolism, as well as cell growth and division all of which are related to blood cells production. Zinc also plays an essential role in the maintenance of nucleic acid structure of genes which equally play regulatory roles in the production of different blood cells. In this study, the observed depression in serum Zn and Cu levels among the cosmetologists and mildly in the HCU may aggravate toxic metal-induced (arising from cosmetic-borne Cd, Pb, Hg, As and Cr) oxidative stress leading to cellular damage and haemolysis.

Conversely, Selenium level was significantly higher in cosmetologists than in HCU and NUC. This finding is suggestive of mild Selenium toxicity in the occupationally exposed group since Selenium is one of the ingredients used in Nail and hair care products as well as some make-up products. Selenium toxicity, in most cases, manifests as chronic dermatitis, loss of hair and brittle nails. The alkali disease, a common complication of selenium toxicity manifests as anorexia, loss of hair and vitality, with myocardial atrophy and liver necrosis (Brodkin et al., 2007; Kapoor and Saraf, 2008; Al-Davies et al., 2011)

Cobalt level was also significantly higher in the cosmetologists than in HCU and NUC. Cobalt is another essential mineral needed in very small amounts in the diet. It is an integral part of vitamin B_{12}, cobalamin, which supports red blood cell production and the formation of myelin nerve coverings. Cobalt, as part of vitamin B_{12}, is not easily absorbed from the digestive tract. The body level of cobalt normally measures between 80 and 300 mcg. It is stored in the red blood cells and the plasma, as well as in the liver, kidney, spleen, and pancreas. Since it is stored in red blood cells, it could be inferred that the raised plasma cobalt levels observed in the cosmetologists may be associated with toxic metal–induced haemolysis, particularly Pb which is reportedly present in cosmetics (Al-Saleh and Al-Enazi, 2011; Chen et al., 2015; Da Silva et al., 2015) suggesting that with increased haemolysis, stored forms of cobalt may be released into the extracellular fluid.

In conclusion, prolonged exposure to cosmetics (through occupational/lifestyle means) appears to lead to a build-up of lethal toxicants in the body, and their antagonistic interactions with nutritionally essential metals may adversely alter trace element homeostasis and aggravate toxicity. This study therefore, surmises that chronic inhalation, ingestion and absorption of cosmetic-borne toxicants by cosmetologists and heavy cosmetic users may, over time, culminate in the depression of essential metals thereby exposing cosmetic users to disease.

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