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Exposure of cadmium via smoking and drinking water on zinc levels of biological samples of malnutrition pregnant women: A prospective cohort study

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ABSTRACT

In present study, the interaction of a toxic (cadmium) and essential element (zinc) was determined in scalp hair of pregnant and non-pregnant women resident in a rural area of Thraparkar, Pakistan, where malnutrition is prevalent. In the malnourished group (pregnant and nonpregnant women), deficiency of the essential element (zinc) due to malnutrition and exposure of toxic metal (cadmium) via non-branded cigarette smoking and drinking groundwater were carried out. For comparative purposes, scalp hair samples were also collected from pregnant and non-pregnant women, residing in Hyderabad city, consuming municipal treated drinking water and smoking branded cigarette, termed as the reference group. The domestic treated and ground water, as well as the branded and non-branding cigarettes were analysed for cadmium (Cd). Whereas Zinc (Zn) and Cd were determined in scalp hair samples of malnutrioned and reference women. The groundwater indicated 5 to 12 fold higher levels of Cd than the WHO recommended value in drinking water. Whereas the content of Cd in locally made non-branded cigarettes was found to be two fold higher than branded cigarettes. These data indicate that the malnourished pregnant and non-pregnant smokers women group had three to four times higher levels of Cd in their scalp hair samples than those values obtained for reference non smokers. Whereas, the content of Zn in scalp hair samples of the reference women was ∼20% higher than the malnourished group.

1. Introduction

The deficiency of essential micronutrients is a severe dilemma in different developing countries (Ehmann and Vance, 1996). The Research Institute of Nutrition, have been reported that about 77% of pregnant women and 44% of children are affected by deficiency of essential trace elements and vitamins (Singh et al., 2017). It was reported in a nutritional survey that generally the intake of zinc (Zn) is reduced by about 50% in pregnant women due to poor diet (Ehmann and Vance, 1996). The adverse impact due to insufficient or/ higher intake of some essential or toxic elements during pregnancy occurs on embryonic development (Ehmann and Vance, 1996). The mortality and morbidity of newborns are both enhanced through the intrauterine period, mainly due to deficiency of essential micronutrients in the mothers (Srivastava et al., 2002). At the present time, the risk of Zn deficiency is a major health problem for pregnant women of developing areas (Aydemir et al., 2003; Black, 2003). It was reported that for normal growth of embryo, Zn is a vital element, especially during last trimester of gestation, when optimum organ development occurs (Caulfield et al., 1998). The major Zn storage in the fetus/embryo is accomplished by metallothionein (a Zn binding protein), which may protect from immediate deficit post-natally.

The persistent exposure of toxic metals through food and nonfood items has been extensively studied (Satarug and Moore, 2004; Haswell-Elkins et al., 2007; Rehman et al., 2018). In non-occupationally exposed populations, major exposures of Cd are linked with different foods such as grains and vegetables, grown in agricultural land irrigated with wastewater, as well as consumption of shellfish. The other important nonfood items (tobacco products) are also the major sources of Cd. Furthermore, the Cd can be interfere with metabolism and transfer of essential micronutrients (Zn and Ca), which are important cofactors of different enzymes to disturb the normal cellular homeostasis of living cells (Yang and Shu, 2015; Kosanovic et al., 2002). The high intake of Cd disrupts the essential function of Ca and Zn in living cell such as nerve signaling and transporting, which results deficits in cellular metabolism (Thevenod, 2009). It was documented that the high exposure

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of Cd, in Zn deficient living systems negatively affects the endocrine system (Kukongviriyapan et al., 2016).

It was reported that absorption and inhalation of Cd is enhanced throughout the pregnancy period (Leazer et al., 2002; Mikolic et al., 2016). The higher effects of Cd exposure during pregnancy can be elucidated due to physiological changes such as raised respiratory rate and reduced gastrointestinal motility, especially when intake of food abnormally low (Moya et al., 2014). During pregnancy, the gut nutrient uptake is upregulated due to greater expression of receptors and transporters, which also increases Cd absorption (Astbury et al., 2015). Cd a is known to accumulate in the gut and lungs related to different routes of exposure, such as through food or cigarette consumption; Cd accumulates in the kidney, liver, placenta, mammary glands, uterus and fetus (Jacobo-Estrada et al., 2016; Nakamura et al., 2012; Mikolic et al., 2015; Blum et al., 2012). The infants are further affected due to high excretion of Cd into the milk (Petersson Grawe and Oskarsson, 2000; Brako et al., 2003).

Women have higher accumulated levels of Cd than men (Nishijo et al., 2004; Vahter et al., 2002), so this accentuates the impact on their reproductive systems and the developing embryo (Thompson and Bannigan, 2008; Nampoothiri and Gupta, 2008; Akesson et al., 2006, 2002). The high uptake of Cd by women is linked with iron deficiency (Akesson et al., 2002; Satarug and Moore, 2004), which is common amongst young women (child bearing age), particularly in pregnancy (WHO, 2002; Kim et al., 2007). Smoking during pregnancy enhances the accumulation of Cd in placenta, which alter the morphology of placental tissues, creates adverse effects on volumes of maternal intervillous space and relative surface areas of fetal capillaries (Iyengar and Rapp, 2001; Bush et al., 2000).

The determination of very low concentrations of trace elements in biological samples requires sophisticated modern techniques (Pohaska et al., 2000). The Cd level in blood is a valid biomarker of recent exposure (Jarup and Akesson, 2009). Whereas scalp hair sampling is a noninvasive and accessible technique that can be used to monitor internally accumulated levels of metals (Pereira et al., 2004; Wang et al., 2009).

The most common methods for the analysis of elements in biological samples are wet acid digestion for the decomposition of organic matrices with concentrated acids using either conservative heating or microwave energy (Memon et al., 2007; Afridi et al., 2006). The most important advantage of microwave digestion are that it needs only a small quantity of sample and oxidizing solvents (Afridi et al., 2006).

Malnutrition is well recognized to cause the micronutrient deficiency labeled as ‘hidden hunger’. Food can be macronutrient rich but lack micronutrients (Hussain et al., 2013). In the largest desert of Pakistan, Tharparkar, child mortality is abnormally high due to hunger and lack of immunity (Rice et al., 2000).

The purpose of present study was to evaluate the exposure of Cd via consumption of drinking water obtained from groundwater and smoking non-branded cigarette on levels of Zn in scalp hair samples of smoker and nonsmokers malnourished pregnant and non-pregnant women. Whereas for comparative purposes, age matched pregnant and non-pregnant women were selected from a developed city of Pakistan (references), where drinking water obtained from municipal treated system, and smoking branded cigarette. The ground and domestic treated water, tobacco of non-branded (Bidi) and branded cigarette were analysed for Cd contents. The biological sample (scalp hair) of both groups were analysed for Zn and Cd.

2. Materials and method

2.1. Geographical description and study population

The malnutrioned women (pregnant and nonpregnant) were selected from different villages of subdistrict Mithi, Tharparkar, Pakistan, which have dry and hot season. Whereas drinking water is mostly obtained from dug well, which is generally brackish to saline and unfit for human consumption. The major issues of malnourished group, living in villages, have low literacy rate and poor socioeconomic status with inadequate basic health necessities.

2.2. Sampling of water and cigarette

The groundwater was sampled three times during study period (2017), from five villages (n = 10 each) of a sub-districts, Mithi, Sindh, Pakistan. For exact sampling point, a global positioning system was used. The dug well have depth from 40 to 60 ft, and water sample were collected manually, kept in cleaned polyethylene bottles and placed in icebox. The domestic treated water samples were collected from the home of selected reference women group. In laboratory, the collected water samples were filtered and treated with 20.0 μL of 10% of concentrated HNO_3 (65%) of analytical grade, obtained from Merck (Darmstadt, Germany), and stored at 4C°.

The nonbranded (Bidi) and five branded cigarette samples (n = 10 of each) were collected from subdistrict Mithi, Tharparkar and Hyderabad city, based on their frequently consumption by the population of Mithi and Hyderabad city, respectively. The samples once in the laboratory were dried for 48 h at 60 °C. Five different branded cigarettes (n = 10 of each) were purchased from local market of Hyderabad city for comparison purpose.

2.3. Subject selection

A cohort study was conducted between January to December 2017, including malnourished pregnant and nonpregnant women, who attending as outdoor patients of gynecological ward of a hospital of Mitthi, Tharparkar, Pakistan. Whereas for comparative purposes other group was selected from gynecological ward of Civil hospital of a developed city Hyderabad (Table 1). A total of 200 females as malnourished group (smoker and nonsmokers pregnant and nonpregnant women), were selected as malnourished non pregnant non smoker women (MNW), malnourished non pregnant smoker women (MNSW), malnourished nonsmoker pregnant women (MNPW) and malnourished smoker pregnant women (MSPW), where poverty and malnutrition is apparent feature. For comparative purposes, 200 females from domestic areas of Hyderabad City, termed as reference group, including reference non pregnant non smoker women (RNW), reference non pregnant smoker women (RNSW), reference nonsmoker pregnant women (RNPW) and reference smoker pregnant women (RSPW) were selected (Table 1). The both group have same age (child bearing age, (20–35 years). The scalp hair samples were collected at third trimester stage of pregnant women. The physical examinations of all selected malnutrioned and reference women groups were carried out in hospitals of Mithi and civil hospital of Hyderabad, respectively. At the start of study, the participants' weight, height, blood pressure and biochemical data were measured and recorded. The body mass index (BMI) of nonpregnant reference and malnutrioned women (RNW) and MNW) was determined. The MNW have BMI, < 18.0 as compared to reference group > 18.0. It was observed that 95% of malnourished group were anemic, have %hemoglobin < 10%, whereas 40% population of

Table 1
Demographics of smoker and nonsmoker referent and malnutrition pregnant and non pregnant women.

	Hyderabad		Tharparkar	
	Non-Pregnant	Pregnant	Malnourished Non- Pregnant	Malnourished Pregnant
Non Smokers	68	73	54	53
Smokers	32	27	46	47
Total	100	100	100	100