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Blood cadmium concentrations and environmental exposure sources in newcomer South and East Asian women in the Greater Toronto Area, Canada

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ABSTRACT

Background: Immigrant women are often identified as being particularly vulnerable to environmental exposures and health effects. The availability of biomonitoring data on newcomers is limited, thus, presenting a challenge to public health practitioners in the identification of priorities for intervention.
Objectives: In fulfillment of data needs, the purpose of this study was to characterize blood concentrations of cadmium (Cd) among newcomer women of reproductive age (19–45 years of age) living in the Greater Toronto Area (GTA), Canada and to assess potential sources of environmental exposures.
Methods: A community-based model, engaging peer researchers from the communities of interest, was used for recruitment and follow-up purposes. Blood samples were taken from a total of 211 newcomer women from South and East Asia, representing primary, regional origins of immigrants to the GTA, and environmental exposure sources were assessed via telephone survey. Metal concentrations were measured in blood samples (diluted with 0.5% (v/v) ammonium hydroxide and 0.1% (v/v) octylphenol ethoxylate) using a quadrupole ICP-MS. Survey questions addressed a wide range of environmental exposure sources, including dietary and smoking patterns and use of nutritional supplements, herbal products and cosmetics.
Results: A geometric mean (GM) blood Cd concentration of 0.39 µg/L (SD: ± 2.07 µg/L) was determined for study participants (min/max: < 0.045 µg /L (LOD)/2.36 µg/L). Several variables including low educational attainment (Relative Ratio (RR) (adjusted)=1.50; 95% CI 1.17–1.91), milk consumption (RR (adjusted)=0.86; 95% CI 0.76–0.97), and use of zinc supplements (RR (adjusted)=0.76; 95% CI 0.64–0.95) were observed to be significantly associated with blood Cd concentrations in the adjusted regression model. The variable domains socioeconomic status (R^2_{adj}=0.11) and country of origin (R^2_{adj}=0.236) were the strongest predictors of blood Cd.
Conclusion: Blood Cd concentrations fell below those generally considered to be of human health concern. However, negative health effects cannot be entirely excluded, especially for those that fall in the upper percentile range of the distribution, given the mounting evidence for negative health outcomes at low environmental exposure concentrations.

1. Introduction

Newcomer women are generally recognized to have a heightened vulnerability with respect to contaminant exposures and associated health outcomes. Elevated body burden concentrations of toxic metals have been reported for newcomer women compared to native-born individuals (Wu et al., 2013; Curren et al., 2014). Higher contaminant concentrations among newcomers are attributed to exposures occurring both pre- and post-migration. Newcomers coming from countries with less stringent environmental regulations are more likely to have been exposed to higher concentrations of contaminants, in addition to exposures occurring at locations of temporary residency during the migration process (Schantz et al., 2010). Poor housing conditions and place of residence following migration, closely tied to the socioeconomic status of many newcomers upon arrival, may also present an increased risk of exposures to contaminants such as lead (Pb)

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(Bakhireva et al., 2013; Schwarz et al., 2015).

The consumption of traditional foods, medicines and supplements, most notably imported items, may also serve as a continuing source of elevated contaminant exposures post-migration (Saper et al., 2004; Buettner et al., 2009). For instance, Buettner et al. (2009) reported findings that women of reproductive age using traditional Chinese and Ayurvedic herbal supplements in the US approximately one month prior to blood collection had Pb concentrations about 20% higher compared to non-users. Imported cosmetics and personal care products such as kohl (as powder, galena, paste and eye pencils) and skin creams are also a recognized potential source of toxic metal exposures among users (Al-Saleh et al., 2009; Cristaudo et al., 2013; Gouitaa et al., 2016).

In addition to toxic metals such as Pb and Hg, exposure to cadmium (Cd) is a particular health concern due to its association with a number of negative health effects. Exposures to Cd are associated with renal toxicity, as well as an increased risk of heart failure and stroke, peripheral arterial disease, osteoporosis, insulin resistance and diabetes (Staessen et al., 1999; Järup et al., 1998; Jin et al., 2004; Järup and Åkesson 2009; Peters et al., 2010). There is also evidence which suggests that those with diabetes may be particularly susceptible to renal dysfunction as a consequence of Cd exposures (Haswell-Elkins et al., 2008). Chronic health effects of Cd are now recognized to occur at lower exposure concentrations than previously thought (Vahter et al., 2007; Mijal and Holzman, 2010). Renal tubular effects, for instance, have been associated with concentrations as low as 0.38 µg/L and 0.67 µg/g creatinine in blood and urine samples, respectively (Åkesson et al., 2005).

Cd exposures are of particular concern for maternal and fetal health. Women appear to be at a greater risk for Cd-related health effects compared to men, attributed both to higher uptake and retention rates and a sex-specific toxicity to this metal (Vahter et al., 2007). Among other factors, low iron storage concentrations, particularly common among women of reproductive age, contributes to a greater absorption rate of Cd in the gastrointestinal tract (Åkesson et al., 2002; Vahter et al., 2007). Higher uptake and accumulation rates of Cd during pregnancy, results in an increased risk for toxicity in both mother and fetus (Osorio-Yañez et al., 2016).

For most non-smoking individuals, diet is the most important source of Cd exposures (Järup et al., 1998; Satarug et al. 2003; Satarug and Moore, 2004). Cd, which is commonly present at elevated concentrations in agricultural soils, is readily taken up by common cultivars, due to its high environmental mobility and solubility (Wiseman et al., 2013, 2014). Cereals and vegetables are the most important dietary sources of Cd. Given the tendency of rice plants to accumulate Cd, populations with higher rice consumption levels, such as those in Asia, are expected to have comparably higher body burden concentrations (Jin et al., 2004; Järup and Åkesson 2009). Meat is also a potential source, with organs such as liver acting as important sources of Cd.

While several studies have reported the occurrence of elevated concentrations of toxic metals in immigrant populations, the biomonitoring data which exists for newcomers is limited, especially for women (Chakravartty et al., 2014). Most studies have tended to focus on Hg and Pb concentrations, stratifying data according to minority status/ethnicity/race, which is then assumed to be representative of concentrations in newcomers. Given the diversity of newcomer populations (including migrants, immigrants and refugees), more data on metal concentrations in newcomer women, especially as a function of world region of origin and associated environmental and culturally-relevant exposure sources, is essential to inform public health actions.

The purpose of this study was to characterize metal blood Cd concentrations among newcomer women of reproductive age (19–45 years of age) and assess potential sources of environmental exposures. This investigation was part of a larger study to examine the blood concentrations of toxic metals (Cd, Pb and Hg) in newcomer women to contribute to critical data needs in an environmental public health context. This paper will focus on the results for Cd, allowing a more in-depth examination of measured concentrations and associations with potential exposure sources.

2. Methods

2.1. Setting

The Greater Toronto Area (GTA) is Canada's largest metropolitan area and has a high newcomer population. About 2,537,400 immigrants were reported to be residing in the GTA in 2011, amounting to 46% of the total population (Statistics Canada, 2013), which highlights the importance of examining exposure sources and concentrations among this population. India, Pakistan, Bangladesh, Sri Lanka and China are primary countries of origin for newcomers to the GTA and, were, therefore, the focus of recruitment efforts for this study.

2.2. Recruitment

A community-based model (O'Fallon and Dearry, 2002) was used to recruit participants. As part of this, peer researchers who were fluent in a total of eight different languages (English, Hindi, Bengali, Urdu, Punjabi, Tamil, Cantonese and Mandarin) were engaged to recruit women from South and East Asian countries between the ages of 19 and 45 years of age. For the purposes of this study, countries falling into the respective groupings of South and East Asia were identified as follows: 1. South Asia=India, Pakistan, Bangladesh, Sri Lanka and Nepal, and 2. East Asia=China (including Hong Kong), Japan and South and North Korea. The study focused on these countries of origin, as they represent the largest ethnic groupings to settle in the GTA. In addition to identifying as South or East Asian, participants were required to have resided in Canada no longer than 5 years, which is in line with the Canadian Census definition of 'recent immigrant' (Statistics Canada, 2013). To capture more recent contaminant exposures within Canada, study participants also had to have resided in Canada for at least 11 of the past 12 months prior to recruitment. In addition, only those having arrived directly from their countries of origin to Canada were considered eligible. Participants include multiple categories of newcomers, including economic and family class immigrants and refugees. Exclusion criteria were as follows: 1. Travel outside of Canada amounting to more than 1 year during their residency period, and 2. < 19 and > 45 years of age at time of recruitment.

2.3. Blood collection and laboratory analysis

Blood Cd is a considered to be a good marker of recent exposures, with a half-life of 3–4 months (Järup and Åkesson 2009). A small proportion of total blood Cd has a longer half-life of about 10 years, however, attributed to long-term Cd storage sources in the body. Blood samples were collected in Lavender Plastic BD # 7863 sampling tubes (Becton-Dickinson) by venipuncture and placed in a cooler with an Ice-Pak. Batched samples were sent by courier to the Institut national de santé publique du Québec (INSPQ), in Québec, Canada, for analysis. Blood samples were diluted 20-fold in a diluent containing 0.5% (v/v) ammonium hydroxide and 0.1% (v/v) octylphenol ethoxylate prior to analysis with an ICP-Q-MS (PerkinElmer). Human blood from healthy volunteers, similarly diluted 20-fold with the same diluent and spiked with different concentrations of a 1 mg/L multi-elements standard solution (SCP Science, PlasmaCal ICP-MS Verification Standard 1; 5% HNO_3, #141-110-011), was used to perform external calibration curves. For calibration purposes and sample analysis, ^{103}Rh was used as the internal standard for Cd. The method limits of detection (LOD), estimated using 3σ of 10 repeat measurements of a representative sample, was 0.045 µg Cd/L (0.4 nmol Cd/L).