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Association of food consumption during pregnancy with mercury and lead levels in cord blood

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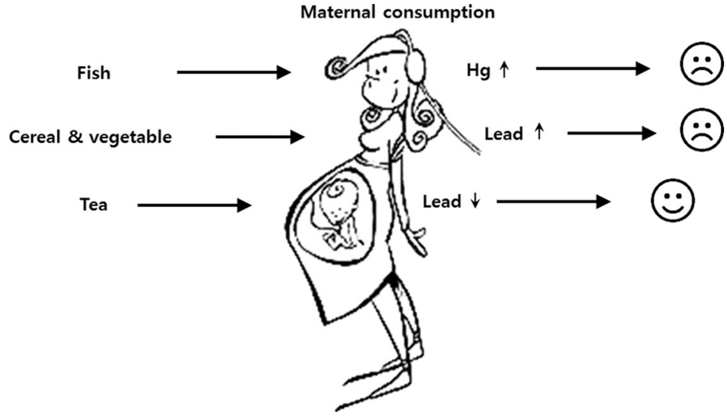
HIGHLIGHTS

- In utero exposure to mercury and lead affect various adverse health outcomes.
- Fish consumption was a major dietary source of mercury exposure in pregnant women.
- Cereal and vegetable consumptions were associated with lead levels in cord bloods.
- Tea consumption restrained increase of lead levels in cord bloods.
- Careful intervention through food consumption should be considered.

GRAPHICAL ABSTRACT



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ABSTRACT

In utero exposure to mercury and lead has been linked to various adverse health effects related to growth and development. However, there was no evidence on the relationship between food consumption during pregnancy and mercury or lead level in cord blood. Therefore we measured mercury and lead levels in bloods, urines, and cord bloods obtained from 302 pregnant women and estimated relationships between food consumption during pregnancy and mercury or lead level in cord blood to identify perinatal mercury and lead exposures originated from foods during pregnancy. Relationship between food consumption and mercury or lead level was estimated using a generalized linear model after adjustment for body mass index (BMI), delivery experience, income, recruitment year, and other dietary factors for mercury and age, BMI, cesarean section, delivery experience, recruitment year, and other dietary factors for lead. Fish consumption was positively associated with mercury level in cord blood ($p = 0.0135$), while cereal and vegetable consumptions were positively associated with

Abbreviations: Hg, mercury; Pb, lead; LOD, limit of detection; HBM, human biomonitoring; BMI, body mass index; GM, geometric mean; BMDL, benchmark dose level.

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Mercury and lead exposures
Pregnant women

lead level in cord blood ($p = 0.0517$ for cereal and $p = 0.0504$ for vegetable). Furthermore, tea consumption restrained increase of lead level in cord blood ($p = 0.0014$). Our findings support that mercury or lead exposure in Korean pregnant women may come from frequent fish and cereal or vegetable consumption while tea consumption may decrease lead exposure in pregnant women. Therefore, careful intervention through food consumption should be considered.

1. Introduction

Mercury (Hg) and lead (Pb) are ubiquitously exposed environmental contaminants. In utero exposures to mercury and lead have been linked to various adverse health effects related to growth and development including preterm delivery, low birth weight, growth delay, and neurodevelopment such as cognition, behavior, and school performance (Andrews et al., 1994; Canfield et al., 2003; Chandramouli et al., 2009; Committee on the Toxicological Effects of Methylmercury, 2000; Hong et al., 2014; Shukla et al., 1991; Taylor et al., 2014). Because mercury and lead in maternal body can easily enter the placenta (Caserta et al., 2013), the fetus may be vulnerable to the adverse effects of the metals (Osman et al., 2000). Because of rapid cell division and differentiation of fetus, relatively low level of exposures to mercury and lead in utero may cause serious influence on fetuses or infants, even at the levels that wouldn't harm their mothers.

Food consumption has been known to be a major exposure source for mercury and lead. Particularly mercury was consistently exposed because it enters the food chain from both natural and anthropogenic sources (Boucher et al., 2014). Although food consumption was recommended as a major exposure source for mercury and lead, major dietary sources, particularly for lead, were not consistent among studies. Moreover, there was limited evidence for dietary exposure sources for mercury and lead in Korean pregnant women (Kim et al., 2012; Kim et al., 2013; Park and Lee, 2013; Paulsen et al., 1996; Saha and Zaman, 2013; You et al., 2014). Furthermore, a safe threshold for mercury and lead levels during pregnancy period was never established (Butler Walker et al., 2006; Gundacker et al., 2010), although levels of concern for mercury and lead in adult bloods were recommended (Taylor et al., 2014).

Therefore, in the present study, we measured levels of mercury and lead in bloods and urines of pregnant women and cord bloods, and evaluated the relation between food consumption and levels of mercury and lead in bio-specimens. Furthermore, we estimated the proportion of risky population for mercury and lead in our Korean pregnant women.

2. Materials and methods

2.1. Study population and sampling

The Children's Health and Environmental Chemicals in Korea (CHECK) study was launched in January 2011 to explore relationships between environmental exposures and health outcomes in children. From its start, the CHECK study has recruited a total of 363 healthy pregnant women with mature term singletone from five hospitals, including Korea University Hospital in Ansan, two Hallym University Hospitals in Seoul and Pyungchon, Soonchunhyang University Hospital in Seoul, and Jeju National University Hospital in Jeju, Republic of Korea, and subjects ($n = 28$) who had pre-term delivery, medical predisposition, or history of occupation exposure were excluded after delivery. Among a total of 335 pregnant women who were included for the present study, only 302 subjects with at least one sample among blood or urine during pregnancy or cord blood were analyzed in this study. Face-to-face interview with the subjects was conducted at enrollment using structured questionnaire for personal demographics and pregnancy-related information, including age, body weight, height, income, gestational period, cesarean section, past delivery experience, and food consumption behavior during pregnancy. Food frequency questionnaire included the information for intake frequency per month of rice, noodle (including wheat flakes noodles and ramen), cereal (including bread), soy (cooked beans, soybean milk, tofu, stew with beans, and adzuki bean), vegetable (white radish, carrot, balloon flower root, seasoned vegetables, tomato, cucumber, chili, welsh onion, and onion), meat (beef, pork, chicken, duck, and pupa and their secondary products), seaweed (sea mustard, kelp, and laver), milk (including yogurt, cheese, ice cream, and cream), fish (external blue colored fish, white flesh fish, raw fish, tuna, salmon, shark, whale, freshwater fish, anchovy, shrimp, crab, lobster, squid, cuttlefish, octopus, shellfish, salted fish, shellfish, shrimp, squid, processed fish and shellfish, and canned fish), peanut butter, beverage (soda and sweeten beverage, coffee, tea, wine, and beer), and retort pouch. Blood and urine samples of pregnant women were collected as soon as they came to hospital at the day before delivery, and cord blood samples were collected at the delivery. All samples were stored at −80 °C until they were analyzed. The present study was approved by the institutional review board at School of Public Health, Seoul National University, Korea (IRB no. 8-2012-04-20), and each study participant provided written informed consent.

2.2. Collection of blood and urine samples and measurement of mercury and lead levels

We measured levels of mercury and lead in bloods and urines of pregnant women and cord bloods. Maternal and cord bloods were collected in K2 EDTA tube (BD Vacutainer K2 EDTA, ref. # 368381, Becton-Dickinson, United Kingdom) to prevent blood coagulation directly with a needle using a vacutainer made from polyethylene (BD Vacutainer SST II Advance, ref. # 367953, Becton-Dickinson, United Kingdom). Maternal single void urine was collected using 50 mL conical tube (BD 352096, Falcon Corp., USA).

Mercury levels in blood and urine samples were measured according to the method 7473 outlined by EPA, USA (2007) with minor modifications. Briefly, 100 μL of whole blood or urine was mixed thoroughly in a roll-mixer, and total mercury levels were determined using an automatic mercury analyzer (SP-3D, Nippon Instruments Co., Japan) using heat-vaporization, gold amalgamation, and cold-vapor atomic absorption technique.

Lead levels in blood and urine samples were measured according to the methods outlined by Butler Walker et al. (2006) and Lee et al. (2012), respectively, with minor modifications. Briefly, lead levels in blood and urine samples were determined using atomic absorption spectrophotometer (AAS; AA6800, Shimadzu, Japan) with graphite furnace (GFA-6500, Shimadzu, Japan) at the wavelength of 283.3 nm with 10 mA current, using 100 μL of whole blood or urine sample in 1 mL of diluent (1% Triton X-100 for blood and 1% Triton X-100 and 1% modifier solution for urine).

In the quality assurance and quality control for mercury and lead measurements, the accuracy and recovery ranges calculated with spiked blood and urine were 90–110% and 85–100%, respectively.

2.3. Statistical analyses

Mercury and lead concentrations under limit of detection (LOD) were assigned as a proxy value of LOD concentration divided by square root of two. Associations among mercury and lead levels in bloods and urines of pregnant women and cord bloods were estimated using