Chemosphere 119 (2015) 485–489

Contents lists available at ScienceDirect

Chemosphere

journal homepage: www.elsevier.com/locate/chemosphere

Elevated prenatal methylmercury exposure in Nigeria: Evidence from maternal and cord blood

Ejeatuluchukwu Obi [a], Charles Okafor [a], Anthony Igwebe [a], Joy Ebenebe [a], Onyenmechi Johnson Afonne [a], Francis Ifediata [a], Orish Ebere Orisakwe [b], Jerome O. Nriagu [c], Niladri Basu [c,d,*]

[a] Faculty of Medicine, College of Health Sciences, Nnamdi Azikiwe University, Nnewi, Nigeria
[b] Toxicology Unit, Faculty of Pharmacy, University of Port Harcourt, Port Harcourt, Nigeria
[c] Department of Environmental Health Sciences, School of Public Health, University of Michigan, Ann Arbor, USA
[d] Faculty of Agricultural and Environmental Sciences, McGill University, Montreal, Quebec, Canada

HIGHLIGHTS

- Mercury is widespread globally but little is known about human exposures in Africa.
- Mercury levels in Nigerian mothers and newborns are higher than other groups.
- 36% of participants had mercury levels exceeding the biomonitoring guideline.

ARTICLE INFO

Article history:
Received 8 May 2014
Received in revised form 10 July 2014
Accepted 14 July 2014
Available online 9 August 2014

Handling Editor: Keith Maruya

Keywords:
Exposure assessment
Mercury
Children's health
Environmental epidemiology
Biomarker

ABSTRACT

Methylmercury is a neurodevelopmental toxicant that is globally distributed though little is known about prenatal exposures in sub-Saharan Africa. The objective of the current study was to measure total mercury levels in cord blood and maternal blood from 95 mother-newborn pairs recruited from hospitals in Nnewi, Nigeria. The secondary aims of the study were to explore if demographic and dietary factors were associated with blood mercury levels, and to explore if mercury levels were associated with any self-reported health outcome and childbirth outcome. Maternal blood mercury levels averaged 3.6 $\mu g\,L^{-1}$ and ranged from 1.1 $\mu g\,L^{-1}$ to 9.5 $\mu g\,L^{-1}$. Cord blood mercury averaged 5.1 $\mu g\,L^{-1}$ and ranged from 1.2 $\mu g\,L^{-1}$ to 10.6 $\mu g\,L^{-1}$. The mean ratio of mercury in paired cord blood to maternal blood was 1.5 and it ranged from 0.4 to 3.2. Mercury in maternal and cord blood were significantly correlated ($r = 0.471$). More than one-third of mothers reported eating fish at least once per day, and a weak ($p = 0.08$) fish consumption-related increase in blood mercury was found. Cord blood mercury was positively and significantly associated with birth weight and length, and head and chest circumference. Mercury levels in 36% of the participants exceeded the biomonitoring guideline associated with the United States Environmental Protection Agency (U.S. EPA) reference dose for mercury. The study shows that pregnant women and their newborns are exposed to methylmercury and that their exposures are higher compared to general populations sampled from other regions of the world.

1. Introduction

Methylmercury is a global contaminant of concern (Mergler et al., 2007). Exposure to methylmercury occurs principally through fish and seafood consumption and thus exposures are ubiquitous among many populations worldwide. Exposures are of concern since methylmercury is a proven neurotoxicant (Clarkson and Magos, 2006) and emerging findings are suggesting that it may also impair the cardiovascular system (Karagas et al., 2012). Methylmercury can cross the placental barrier and a number of epidemiological studies have established that methylmercury is of threat to neurodevelopment (Mergler et al., 2007). The accepted biomarkers of methylmercury exposure include measurements of total mercury levels in blood and hair (Mergler et al., 2007).

Much of the evidence concerning human population exposures to methylmercury and associated health effects have been drawn

* Corresponding author at: CINE Building, 21111 Lakeshore Rd., Faculty of Agricultural and Environmental Sciences, McGill University, Montreal, Quebec H9X 2T9, Canada. Tel.: +1 514 398 8642.
E-mail address: Niladri.basu@mcgill.ca (N. Basu).

http://dx.doi.org/10.1016/j.chemosphere.2014.07.038
0045-6535/

from studies involving susceptible groups in which exposures are relatively high, or in developed countries which have the resources and capabilities to conduct biomonitoring programs (Mergler et al., 2007; Karagas et al., 2012). However, there are many geographic regions and populations for which we know little about methylmercury exposures. One such region is Sub-Saharan Africa, and in particular the region of West Africa. In West Africa, there have been few studies concerning mercury exposure but largely in terms of occupational exposures in artisanal small-scale gold mining communities (Paruchuri et al., 2010; Kwaansa-Ansah et al., 2010). These studies, for example, have documented rather high exposures of workers to elemental mercury (>20% had high urinary mercury levels, more than 10 $\mu g\ L^{-1}$; Paruchuri et al., 2010). Little is known about methylmercury exposures amongst the general population, and to our knowledge, none concerning exposures *in utero*.

The aim of the current study was to increase understanding of prenatal exposures to methylmercury in West Africa. Here we focused on Nigeria. Nigeria is the most populous country in Africa, and seventh worldwide. The country is considered an emerging market, and much of its economy is fueled by natural resources such as oil and gas. Despite the potential for widespread mercury contamination, there is limited epidemiological evidence. The current study was conducted by capitalizing upon resources of an existing cross-sectional study of mother–child pairs recruited from hospitals in the city of Nnewi which is located in the Anambra State in southeastern Nigeria. The study was designed to assess a number of urban environmental health issues in relation to maternal exposures during pregnancy and health outcomes. The main aim of the current study was to measure total mercury levels in cord blood and maternal blood from 95 mother-newborn pairs. Total mercury content in blood is reflective of methylmercury exposure (Mergler et al., 2007). Secondary aims were to explore if demographic and dietary factors may be related to the aforementioned biomarkers of mercury exposure, and to explore if mercury biomarker values could be related to any self-reported health outcome and childbirth outcome.

2. Methods

2.1. Sample population

Pregnant women ($n = 95$) in their third trimester were recruited between January and November of 2011. Participants were drawn from three hospitals (The Light Hospital, Divine Specialist Hospital, Chidera Hospital) in the city of Nnewi, Nigeria. Individuals with gestational diabetes, gestational hypertension and multiple births were excluded from the larger study. Information concerning the pregnancy, delivery, and birth outcomes was obtained from medical records. Trained personnel at the aforementioned hospitals collected biological samples. Venous maternal whole blood samples and umbilical cord blood samples (4–6 mL) were collected into BD Vacutainer tubes certified for trace metals analysis and immediately stored at −20 °C until analysis.

Informed consent and signed forms were obtained from each participant prior to enrolment. All aspects of this study were approved by the ethics and research committees of Nnamdi Azikiwe University Teaching Hospital (Nnewi) and the National Health Research Ethics Committee of Nigeria, as well as the University of Michigan Institutional Review Board.

2.2. Survey instruments

Sociodemographic factors were collected, such as mother's age at delivery, occupation, highest education level achieved, housing tenure, and parity. A 44-point survey on self-reported health symptoms was administered. A 40-point survey on food and drink items (ranged from zero to more than twice daily) was administered to gauge usual intakes over the course of pregnancy. This questionnaire included four items related to fish consumption: fish in general, dried fish, stockfish, and canned tuna.

2.3. Mercury analyses

Measurement of total mercury in blood was carried out using a Direct Mercury Analyzer 80 (DMA-80, Milestone Inc., CT) according to U.S. EPA Method 7473 as previously described (Basu et al., 2010; Paruchuri et al., 2010). Briefly, blood samples were vortexed and 1 mL was then placed into a quartz sampling boat. Upon entry into the analyzer, the blood sample was decomposed and the liberated mercury vapor was detected by an absorbance cell. Quality assurance steps included daily instrument calibration, procedural blanks, replicate runs, and certified blood reference standard from the Institut National de Santé Publique du Québec (INSPQ).

The analytical detection limit of mercury was 0.7 ng (range: 0.2–1.8 ng, $n = 10$). Using blood reference material from the Institut National de Santé Publique du Québec (INSPQ), the mean analytical accuracy was 99.9% (range: 97.1–103.3%, $n = 11$). The mean precision (reproducibility of replicates) was 6.0% (range: 0.3–19.2%, $n = 15$).

2.4. Data analyses

The data were initially analyzed using descriptive statistics and graphical displays. Univariate calculations (e.g., central tendencies, percentiles, and variances) were performed to describe the blood mercury levels and survey information. Bivariate calculations were used to relate mercury levels with demographic characteristics, fish consumption data, and other measures. Spearman and/or Pearson correlations were used to compare the relationship of the mercury levels. Data are reported as mean ± standard deviation, unless otherwise indicated. Data were analyzed using SAS 9.2 (SAS Institute Inc. Cary, NC).

3. Results

3.1. Demographics

Participant demographics are reported (Table 1). Briefly, the average age of the mother was 28 years and their mean self-recalled weight prior to pregnancy was 74 kg. The mothers reported living in their current town an average of 9 years (range 1–38 years; median was 5 years). Nearly one-fifth (19%) of the mothers reported owning their home, and the rest were renting. All of the mothers reported having a primary school education, 74% reported completing secondary school, and 12% have received a university degree. In terms of occupation, 66% of participants reported working in the trades and commercial sector and 12% reported working in an office.

Table 1
Characteristics of participating mothers and newborns from whom we report upon mercury biomarker measurements.

	Mean	Standard deviation	Range (min–max)
Maternal age (yrs)	28.3	4.6	18–38
Maternal height (cm)	163.6	7.7	148–187
Maternal weight (kg)	74.3	12.0	52–116
Birth weight (kg)	3.4	0.5	2.3–5.1