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Trends in and factors affecting the observed levels of urinary inorganic and total blood mercury among US children, adolescents, adults, and senior citizens over 2005–2012☆

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ABSTRACT

Data from National Health and Nutrition Examination Survey (NHANES) for 2005–2012 were used to (i) study adjusted and unadjusted trends in the levels of urinary inorganic mercury (UIHG) and total blood mercury (TBHG) and (ii) factors that affect the observed levels of UIHG and TBHG among children aged 1–5 (CHLD15) and 6–11 (CHLD611) years, adolescents aged 12–19 years (ADOL), adults aged 20–64 years (ADLT), and senior citizens aged > = 65 years (SNR). Decrease in adjusted levels of UIHG for each 2-year NHANES cycle for CHLD611 was 0.08114 ng/L, 0.08379 ng/L for ADOLs, and 0.12 ng/L for ADLTs. Decreases in adjusted levels (AGM) of TBHG for each 2-year NHANES cycle were: 0.0632 ng/L for CHLD15, 0.10239 ng/L for CHLD611, 0.06424 ng/L for ADOLs, and 0.056088 ng/L for ADLTs. Among CHLD15 (0.34 vs. 0.39 μg/L, $p < 0.01$) and CHLD611 (0.42 vs. 0.44 μg/L, $p = 0.04$), males had lower AGMs for TBHG than females but among ADLTs (0.84 vs. 0.80 μg/L, $p < 0.01$) and SNRs (0.82 vs. 0.71 μg/L, $p < 0.01$) the reverse was true. For UIHG, for ADLTs (0.33 vs. 0.45 μg/L, $p < 0.01$) and SNRs (0.27 vs. 0.35 μg/L, $p < 0.01$) males had lower AGMs than females. Irrespective of age, those who were in unclassified race/ethnic group had the highest AGMs when compared with non-Hispanic whites, non-Hispanic blacks, and Mexican Americans and the differences, more often than not, were statistically significant ($p < 0.01$). Irrespective of age, fish and shellfish consumption during the last 30 days was associated with higher AGMs for both UIHG and TBHG than when fish and shellfish were not consumed and the differences were always statistically significant ($p < 0.01$). Nonsmoker ADLTs (0.86 vs. 0.78 μg/L, $p < 0.01$) and SNRs (0.83 vs. 0.71 μg/L, $p < 0.01$) were found to have higher adjusted levels of TBHG than smokers. It is hypothesized that constituents in tobacco smoke may accelerate excretion of mercury from the body.

1. Introduction

Consumption of methyl mercury (MeHg), the predominant from of organic mercury, has been of concern for females of child-bearing age because of its potential for prenatal exposure. MeHg can easily cross the placenta and blood-brain barrier (EPA, 2015) and based on a review of existing literature, US Environmental Protection Agency (EPA) has described that health effects observed in the prenatally exposed children include cerebral palsy, intellectual disability, deafness, and blindness (EPA, 2015). Impact of prenatal exposure to MeHg among 1022 consecutive singleton births during 1987–1988 in the Faroe Islands at the age of 14 years was reported by Debes et al. (2006). Those with prenatal exposure to MeHg were found to be associated with deficits in finger tapping speed, reaction time on a continued performance task, and cued naming. And at the age of 22 years, deficits in Boston Naming Test and other tests of verbal performance were found to be associated with the cord-blood mercury concentrations (Debes et al., 2016). Kim et al. (2017) analyzed data from a birth cohort from China and another birth cohort from Korea and a negative association between maternal and cord blood Hg and birth weight was discovered. Ryu et al. (2017) found blood Hg levels at late pregnancy and early childhood to be associated with autistic behaviors in children at 5 years

Abbreviations: ADLT, adults aged 20–64 years; ADOL, adolescents aged 12–19 years; AGM, adjusted geometric mean; BMI, body mass index; CHLD15, children aged 1–5 years; CHLD611, children aged 6–11 years; LOD, limit of detection; MA, Mexican American; MeHg, methyl mercury; NHANES, National Health and Nutrition Examination Survey; NHB, non-hispanic black; NHW, non-hispanic white; OTH, other unclassified race/ethnicities; PIR, poverty income ratio; SAS, statistical analysis system; SNR, senior citizens aged > = 65 years; TBHG, total blood mercury; UGM, unadjusted geometric mean; UIHG, urine inorganic mercury

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of age. Based on these studies, it can be said that methyl mercury is neurotoxic.

Positive association between dental fillings and total blood mercury (TBHG) and MeHg was reported by Yin et al. (2016). MeHg was found to be associated with subclinical autoimmunity among reproductive-age females (Somers et al., 2015). Lin et al. (2014) reported positive association between MeHg and liver enzymes. Gallagher et al. (2013) found positive association between TBHG and measles antibody concentrations among US children aged 6–11 years. Among adults aged > = 20 years, TBHG was found to be inversely related to total triiodothyronine and thyroxine and free triiodothyronine (Chen et al., 2013). Sheehan et al. (2012) found higher levels of TBHG among reproductive age females who came in contact with chronic hepatitis B virus compared to those who did not. Cave et al. (2010) reported a positive association between Hg exposure and elevation in the levels of serum alanine aminotransferase.

Among pregnant and non-pregnant females aged 16–49 years, the most significant predictor of TBHG was reported to be the seafood consumption during the last 30 days (Razzaghi et al., 2014) and other predictors associated with TBHG levels > = 3.5 μg/L were age > = 35 years, education > high school, and poverty income ratio > 3.501. Buchanan et al. (2015) reported MeHg levels to be highest among Asian females of child-bearing age and among Asians aged > = 50 years and, frequency of fish consumption was reported to explain 21–23% of variability in the levels of MeHg. Rothenberg et al. (2015) reported on the effect of obesity on the metabolism and distribution of MeHg and an inverse association between body mass index (BMI) and TBHG among adults aged > = 20 years and BMI z-score and TBHG among children aged 2–19 years was reported. Mortensen et al. (2014) reported Asians to have the highest concentrations of MeHg and TBHG followed by non-Hispanic blacks (NHB) and Mexican Americans were found to have the lowest levels of MeHg. In addition, being male, older individuals, and adults with greater educational attainment was associated with higher MeHg concentrations (Mortensen et al., 2014). Seafood consumption was reported to be associated with TBHG among US youth aged 1–19 years (Nielsen et al., 2015). Nielsen et al. (2014) reported positive association between the consumption of tuna, salmon, high-mercury fish, and other seafood and TBHG.

To the best of this author's knowledge, a study that has evaluated trends in the observed levels of Hg in the general US population has not been conducted. Consequently, this study was undertaken to study (i) trends in adjusted and adjusted levels of urinary inorganic mercury (UIHG) and TBHG over 2003–2012 among US children aged 1–5 (CHLD15) and 6–11 (CHLD611) years, adolescents aged 12–19 years (ADOL), adults aged 20–64 years (ADLT), and senior citizens (SNR) aged > = 65 years and (ii) factors that affect the observed levels of UIHG and TBHG among CHLD15, CHLD611, ADOL, ADLT, and SNR. Data from National Health and Nutrition Examination Survey (NHANES) for the years 2005–2012 were selected for this study. It should be noted that data for blood MeHg was not available for the entire study period and as such were not selected for analyses for the purpose of this study.

Table 1
Weighted percent sample sizes by age, gender, and race/ethnicity for urinary inorganic mercury and total blood mercury. Data from National Health and Nutrition Examination Survey 2003–2012.

Age in years	Category	Urine Inorganic Mercury		Total Blood Mercury	
		N	Weighted Percent	N	Weighted Percent
1–5	Total			4245	100.0
	Male			2191	52.0
	Female			2054	48.0
	Non-Hispanic White			1190	52.6
	Non-Hispanic Black			1106	15.1
	Mexican American			1258	17.7
	Others			691	14.7
6–11	Total	1819	100.0	4858	100.0
	Male	916	51.5	2437	51.8
	Female	903	48.5	2421	48.2
	Non-Hispanic White	485	55.6	1298	55.8
	Non-Hispanic Black	514	14.4	1341	14.7
	Mexican American	518	14.7	1417	15.6
	Others	302	15.3	802	13.9
12–19	Total	2624	100.0	7367	100.0
	Male	1370	51.2	3851	51.5
	Female	1254	48.8	3516	48.5
	Non-Hispanic White	729	60.0	2010	60.0
	Non-Hispanic Black	808	15.1	2274	14.8
	Mexican American	732	13.1	2053	12.7
	Others	355	11.9	1030	12.5
20–64	Total	6280	100.0	18280	100.0
	Male	3136	49.7	9085	49.7
	Female	3144	50.3	9195	50.3
	Non-Hispanic White	2649	67.7	7841	67.8
	Non-Hispanic Black	1434	12.0	4051	11.4
	Mexican American	1152	8.8	3389	8.9
	Others	1045	11.5	2999	11.8
> = 65	Total	2149	100.0	6239	100.0
	Male	1104	44.5	3141	43.9
	Female	1045	55.5	3098	56.1
	Non-Hispanic White	1269	81.7	3811	81.9
	Non-Hispanic Black	398	8.3	1040	7.8
	Mexican American	247	3.1	727	3.3
	Others	235	6.9	661	7.0

2. Materials and methods

2.1. Data source and data description

Data from NHANES for 2003–2012 for demographics, body measures, urine inorganic mercury (UIHG), total blood mercury (TBHG), serum cotinine, and first day total dietary intake were downloaded and merge matched by the ID of NHANES participants. While data for UIHG were available for one-third of NHANES participants aged > = 6 years, data for TBHG were available for all NHANES participants aged > = 1 year. The only data selected for use from first day total dietary intake files were self-reported consumption of shellfish and fish during the last 30 days. However, these data for 2003–2004 were available for only those who were aged 1–5 years and for females aged 16–49 years. As such, adjusted analyses for those aged > = 6 years were restricted for the period 2005–2012 only. All those with serum cotinine values < 10 ng/mL were defined as nonsmokers and those with serum cotinine values > = 10 ng/mL was defined as smokers. However, all those aged < 12 years were assumed to be nonsmokers irrespective of their serum cotinine levels. A total of 12872 participants were available for analyses of UIHG data and a total of 40989 participants were available for analyses of TBHG data. Detailed sample sizes by age, gender, and race/ethnicity are provided in Table 1. For the purpose of this study, separate analyses were done for those aged 1–5 (CHLD15), 6–11 (CHLD611), 12–19 (ADOL). 20–64 (ADLT), and >