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Prenatal exposure to mercury in a prospective mother–infant cohort study in a Mediterranean area, Valencia, Spain

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ABSTRACT

Background: Mercury (Hg) is a ubiquitous pollutant that negatively affects fetal and child neurodevelopment at accidental high-dose exposure. Some studies indicate that Mediterranean populations could be at risk of prenatal exposure to mercury through fish consumption.

Objectives: To assess the prenatal exposure to total mercury (T-Hg), both inorganic and organic, in newborns by analyzing the T-Hg concentration in cord blood, and to evaluate the role of maternal fish consumption in this exposure.

Methods: In the context of a multi-center project (INMA project), a prospective birth cohort was set up in Valencia, Spain, from 2005 to 2006. A total of 253 newborns were included in this study. We compared cord blood T-Hg concentration by levels of fish intake assessed by a food frequency questionnaire completed at 28–32 weeks of gestation. Maternal covariates were obtained through a questionnaire.

Results: The geometric mean of T-Hg at birth was 9.9 μg/L (95% CI: 9.0, 10.8). Seventy five percent of cord blood samples were above the estimated level assumed to be without appreciable harm (5.8 μg/L). Women who consumed a portion of large oily fish, lean fish, or mixed fried fish two or more times per week had mean cord blood levels 1.6, 1.4 and 1.3 times higher, respectively, than those who rarely or never consumed fish. Other factors such as the mother's age, country of origin, smoking and season of delivery were also significantly and independently associated with cord blood T-Hg concentrations.

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Conclusions: Newborns from a Mediterranean area presented elevated levels of T-Hg in cord blood. Higher concentrations of T-Hg were related to maternal fish intake, particularly in the case of large oily fish species.

1. Introduction

Mercury (Hg) is a naturally occurring metal that is widespread in the environment. Anthropogenic sources from industry, combustion of fossil fuels, and mining activities contribute to the atmospheric burden and to the pollutant spreading to parts of the ecosystem where it was not found previously (International Programme on Chemical Safety, 1991; Ontario Public Health Association, 2004). Hg exists in several forms, as elemental mercury (e.g. dental amalgam), as inorganic compounds when combined with other elements (e.g. skin-lightening creams) or as organic compounds when combined with carbon (Centers for Disease Control and Prevention, 2005). Hg is transformed into methylmercury (MeHg), its most toxic, organic form, by microscopic organisms when atmospheric Hg is deposited on contaminated soils or water surfaces. In this form, it is capable of bioaccumulation in the marine food chain (Sanfeliu et al., 2003). The most common route of human exposure to mercury is through the consumption of fish contaminated with MeHg (International Programme on Chemical Safety, 1991; Centers for Disease Control and Prevention, 2005; US Environmental Protection Agency, 2007).

The toxic effects of MeHg became evident after episodes of accidental poisoning in Japan and Iraq due to the consumption of highly contaminated fish and grain. Its neurotoxic effects were seen in adults and the children of poisoned mothers, the latter being more seriously affected due to the vulnerability of the developing brain (Myers and Davidson, 2000; Weiss, 2000; Grandjean and Landrigan, 2006). In two communities with a high fish and sea mammals intake, such as the Republic of Seychelles and the Faroe Islands, the effects of prenatal exposure to MeHg on fetal and child neurodevelopment and behavior were found to be inconsistent. While in the Seychelles study no detrimental effects on children's cognitive functions have been found to date, except for one adverse association among 48 neurodevelopmental endpoints (Myers et al., 2003; Davidson et al., 2006), neuropsychological impairments in memory, attention, language, and to a lesser extent, visuospatial perception and motor functions have been noted in exposed children in the Faroes (Grandjean et al., 1997).

Data from the above cohorts together with data from a New Zealand cohort study (Crump et al., 1998) provided the basis for the National Research Council's and US EPA's 2001 validation of a Reference Dose (RfD), an estimate of a daily exposure where no appreciable risk of deleterious effects during a lifetime would occur, for MeHg intake of 0.1 μg/kg of body weight per day (National Research Council, 2000; US Environmental Protection Agency, 2007). This level was derived after applying an uncertainty factor of 10 to the lower 95% confidence limit for which significant neuropsychological effects in the offspring have been observed (58 μg/L in whole cord blood) (US Environmental Protection Agency, 2007). This level would correspond to a mercury concentration of 5.8 μg/L in whole cord blood (Centers for Disease Control and Prevention, 2004). However, other agencies have recommended regulatory levels that are significantly less stringent than EPA's reference dose. The Agency for Toxic Substances and Disease Registry has established a daily intake of MeHg of 0.3 μg/kg of body weight per day as the Minimal Risk Levels (Agency for Toxic Substances and Disease Registry, 2007). The Food and Agriculture Organization (FAO) and the World Health Organization (WHO) revised in 2003 and confirmed in 2006 the recommendation for a safe mercury intake from food to a level of 1.6 μg/kg of body weight per week (0.22 μg/kg per day) (United Nations Environment Programme, 2007).

Besides the debate on safe exposure levels, from a public health perspective what remains to be elucidated is whether lower prenatal exposures than in the three mentioned cohorts, i.e. in communities with lower fish intake or less contaminated fish, may cause subtle adverse neurodevelopmental effects in fetus and children (Davidson et al., 2006; Daniels et al., 2004; Oken et al., 2005; Jedrychowski et al., 2006). In addition, the effects of prenatal Hg exposure on preterm birth have also been described recently (Xue et al., 2007).

Spain is a country with a relatively high consumption of fish in some regions (Amiano et al., 2001; Welch et al., 2002) and has been ranked as the second largest consumer of fish in the world behind Japan (Ministerio de Sanidad y Consumo, 2007). It has been reported that the Mediterranean basin contains important cinnabar deposits and that fish at the top of the marine food chain have a higher mercury content than the fish found elsewhere (Renzoni et al., 1998). In the 1980s, the WHO Regional Office for Europe initiated an evaluation of exposure to Hg as part of the Programme for Pollution Monitoring and Research in the Mediterranean sea (MED POL). The results showed a wide range of hair Hg levels in pregnant women and fishermen with particularly high levels in a study of fishermen's families along the Dalmatian coast (Buzina et al., 1995). A more recent pilot study in Greece showed mean total hair Hg concentrations of above 1 ppm in pregnant women from several islands of the Eastern Aegean region (Gibicar et al., 2006). In a study conducted in eight European countries and Israel, evaluating the benefits-risks of fish consumption on myocardial infarction, the Spanish centers showed the highest levels of mercury measured in toenails (Guallar et al., 2002). In two studies in Spanish children, one showed that children in the highest fish intake groups had mercury levels in hair higher than 1 ppm (Batista et al., 1996) and the other found that in 31% of children in a region near an electrochemical factory, the level in hair was above 1 ppm (Montuori et al., 2006).

The aim of the present study is to assess the degree of prenatal exposure to mercury by measuring the total mercury levels in cord blood of a prospective mother–infant cohort in Valencia, Spain, and to evaluate the role of fish consumption and other factors in this exposure.