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# Body burdens of mercury in lower Hudson River area anglers

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**Abstract**

The Hudson River has been a federally designated Superfund site for over 20 years. Discharges of industrial waste and of treated and untreated sewage and atmospheric deposition have introduced mercury and other persistent pollutants to the Hudson River ecosystem. Despite New York and New Jersey health advisories, many local anglers and their family members continue to consume fish caught from the river. To evaluate associations between body burden of mercury and local fish consumption, we conducted a cross-sectional study of 191 anglers recruited from piers and fishing clubs. Participants were administered a questionnaire to obtain information on local fish consumption, and 65% (124 individuals) provided a blood sample used to determine mercury levels. Mercury levels ranged from below the limit of detection (0.75 ng/mL) to 24.0 ng/mL. Participants who reported eating locally caught fish had significantly higher levels of mercury (mean ($M$) = 2.4 ng/mL, standard error (SE) = 1.2) than anglers who never ate locally caught fish ($M$ = 1.3 ng/mL, SE = 1.1). A positive dose–response pattern was also observed, where participants who reported eating locally caught fish more than once a week had higher mercury levels ($M$ = 2.6 ng/mL, SE = 1.1) than anglers eating fish less frequently ($M$ = 2.0 ng/mL, SE = 1.2) or never at all ($M$ = 1.3 ng/mL, SE = 1.1). These findings indicate that consumption of fish caught from the lower Hudson River area is a route of human exposure to mercury for the angling community.


*Keywords:* Mercury; Human; Fish consumption; Anglers; Hudson river

## 1. Introduction

Mercury is a ubiquitous environmental contaminant. Emissions of inorganic mercury to the atmosphere, derived primarily from coal combustion and waste incineration (US EPA, 1998), contribute significantly to global atmospheric loading (Lindqvist, 1994) and lead to enhanced atmospheric deposition of mercury in the vicinity of combustion sources (Mason et al., 1994) and in more distant locales. An additional source of mercury to natural water systems such as the lower Hudson River and the adjacent New York–New Jersey (NY–NJ) harbor complex is direct input from industrial establishments and discharge of municipal wastes. Inorganic mercury that reaches sediments of rivers, lakes, and oceans can be biologically transformed to methylmercury, an environmentally persistent neurotoxic compound capable of bioaccumulation in the marine food web (Gilmour et al., 1992; Krabbenhoft et al., 1995; Fitzgerald et al., 1998).

Methylmercury is a potent neurotoxicant, especially to the developing brain of the fetus. The neurotoxic effects of methylmercury were first documented in the 1950s when the population of Minamata City, Japan was exposed to high levels of methylmercury through contaminated fish consumption (Harada, 1978, 1995). Clinical observations of Iraqi children, accidentally exposed to high levels of methylmercury through grain contamination, also showed neurological deficits, especially in infants (Amin-zaki et al., 1978). Studies designed to investigate the human health effects of mercury exposure at lower doses have been underway for the past several decades. In a study undertaken in the Faroe Islands fetal exposure to methylmercury from maternal fish consumption has been shown to be associated with neurological deficits in offspring that persist at least through the teen years (Amin-zaki et al.,

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1978; Murata et al., 2004; Steuerwald et al., 2000). A study undertaken in New Zealand has shown a similar association (Crump et al., 1998). However, data collected from children residing in the Republic of Seychelles have shown little evidence of an association between neurological development in children and maternal mercury exposure (Davidson et al., 1998; Myers et al., 2000, 2003). Based on a critical analysis of these studies, The National Academy of Sciences has concluded that methylmercury is a fetal neurotoxicant even at low levels of exposure and that the harmful health effects associated with methylmercury exposure for pregnant women outweigh the potential benefits of omega-3 fatty acids and other nutrients from fish consumption (Keiding et al., 2003; Landrigan and Goldman, 2003; Lyketsos, 2003; NAS, 2000). Other researchers have shown that exposure to mercury-contaminated fish may carry a risk of cardiovascular complications for men also and the development of a reference dose based on these outcomes has been suggested (Guallar et al., 2002; Stern, 2005). Currently, the reference dose for mercury consumption set by federal agencies is 0.1 μg/kg of body weight per day (US EPA, 2003) with a recommended resting state of 5.8 ng Hg/ml blood (NAS, 2000). The New York State Department of Health recommends that no person should eat more than one meal of fish per week from the lower Hudson River area or any of the state's freshwaters (NYSDOH, 2005).

A positive relationship between fish consumption and human body burdens of mercury has been found in fish-eating populations worldwide (Grandjean et al., 1992; Kosatsky et al. 2000; Evens et al., 2001; Bjornberg et al., 2003; Myers et al., 2003; Schober et al., 2003). In the United States, a recent study using data from 1709 women from the National Health and Nutrition Examination Survey (NHANES) found that in 1999–2000 mean blood levels of mercury were higher for women who reported eating both commercial fish and shellfish in the previous 30 days (1.7 ng/mL) than for women who never ate any (0.4 ng/mL) (Schober et al., 2003). Blood levels of mercury in US angling populations have been reported to be as high as 2.2 ng/mL for people living near the Great Lakes area and 4.4 ng/mL for Chippewa Indians living near the Wisconsin Lake (Peterson et al., 1994; Anderson et al., 1998). The levels of mercury found in these US populations are similar to those reported for Swedish (4.0 ng/mL) and Canadian (3.0 ng/mL) anglers (Svensson et al., 1995; Kosatsky et al., 2000).

A previous study of anglers in the Newark (New Jersey) Harbor complex area found that nearly 70% of anglers studied ate locally caught fish or crabs at least once a month during the fishing season, with 8–25% consuming more than 1.5 kg/month (Burger, 2002). A related study found that, in a survey of anglers in the same area, while 60% of those surveyed were aware of New Jersey State fishing advisories, 62% of respondents were unaware of specific health effects associated with the consumption of locally caught fish and shellfish (Pflugh et al., 1999).

Although studies in various locales have shown associations between fish consumption and elevated methylmercury exposure, to date, no comprehensive studies of anglers in the lower Hudson River area documenting the human body burdens of the environmental chemicals found in locally caught fish have been published. Since the Hudson River is a Superfund site with elevated levels of mercury in sediments and fish, this study was designed to evaluate the association between local fish intake and blood levels of mercury in humans and to document the persistence of mercury in the lower Hudson River area ecosystem.

## 2. Materials and methods

### 2.1. Study participants and sampling

During the summer and fall fishing seasons from 2001 to 2004, we conducted a cross-sectional study among urban anglers in the lower Hudson River and adjacent NY–NJ harbor complex. Anglers were recruited on fishing piers (in Elizabeth, Englewood Cliffs, and Bayonne, NJ; in West Harlem, New York City and at Canarsie Pier in Brooklyn, NY) and at fishing clubs (in Ridgefield Park, NJ; in Staten Island, NY) (Fig. 1). A typical recruitment event was staffed by the principal investigator, a research coordinator, a certified phlebotomist, and two additional trained interviewers. During questionnaire-based interviews participants were asked questions on their fishing practices, consumption patterns, and demographic parameters. In addition, participants provided information on the frequency and amount of intake for the following species: American eel, blackfish, bluefish, blue crab, clam and mussel, flounder, fluke, striped bass, tommy cod, weakfish, white catfish, white perch, and general commercial fish. One hundred and ninety-one anglers participated in the study between 2001 and 2004. One hundred forty-nine (78%) of the participants provided blood samples and 126 of these had sufficient whole blood for mercury analysis (Table 1). However, because body mass index (BMI) or age was not available for 2 participants the final data set includes 124 anglers. A comparison of anglers providing whole-blood samples and those who did not found very few differences between the two groups, except that blood donors (a) were slightly younger (mean age (in years) = 52 versus mean age = 54) and (b) reported ever eating their local catch more frequently (84% versus 72%).

### 2.2. Analytical techniques

Whole-blood samples (10 mL) were collected using venipuncture, stored at −20 °C and analyzed for total mercury content using a UV-absorptiometer (Mercury Monitor 1235, Laboratory of Data Control, Milton Roy, FL) at the University of Rochester. Methods for this analysis have been described in detail elsewhere (Magos and Clarkson, 1972). The limit of detection (LOD) was 0.75 ng/mL. Seronorm (Sero AS, Norway) was used as an external standard prior to sample analysis. A mean value of 8.0 ng/mL was observed, which is in close agreement with the mean value (8.2 ± 0.9 ng/mL) reported by the manufacturer. Unidentified replicate samples were also analyzed for quality assurance.

### 2.3. Statistics

Consumption of local fish by respondents was measured based on self-reported intake. First, a dichotomous variable was created where anglers reporting eating any of the species of fish at any frequency were categorized as "eating locally caught fish" and respondents reporting not eating any species of fish were categorized as "not eating locally caught fish." Second, a categorical variable was created where average frequency of fish intake was measured by summing the weighted frequency of reported intake across species of fish, using the following