ENVIRONMENTAL EXPOSURE TO PCBS AMONG RESIDENTS OF UPPER HUDSON RIVER COMMUNITIES

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Introduction

Due to discharges from General Electric (GE) capacitor plants in Fort Edward and Hudson Falls, NY, USA, the extent of the PCB pollution along the upper Hudson River exceeds that of many other contaminated river systems. As a result, the US Environmental Protection Agency (USEPA) has classified a 200-mile section of the river from Hudson Falls to New York City as a National Priority List site, making it one of the largest Superfund sites in the USA. In 2002, the USEPA issued a federal Superfund Record of Decision which called for targeted environmental dredging and removal of approximately 2.65 million cubic yards of PCB-contaminated sediment in the upper River. The USEPA and GE continue to negotiate the details of the project, which is planned to commence in 2007.

Despite the high levels of PCBs in the environment along the upper Hudson River, no study to date has investigated the extent to which local residents have been exposed. Consequently, this article assesses the impact of dietary and residential exposure on PCB body burdens among older men and women living along contaminated portions of the River. Specifically, we hypothesize that higher serum PCB concentrations will be observed among 1) persons who have eaten Hudson River fish, and 2) persons who live near or downwind of the River and other local PCB sites. We also hypothesize that serum PCB concentrations will be greater among the residents of these upper River communities compared to a control community. The current study is part of an ongoing project designed to evaluate the neuropsychological effects of PCBs. The focus is upon older persons because PCBs may exacerbate the neurodegenerative processes associated with aging.[1, 2]

Materials and Methods

The study population consisted of men and women aged 55 to 74 who resided in Hudson Falls or Fort Edward, NY for at least 25 years. Restricting length of residence to 25 years or more ensured that participants resided in the study area when the capacitor facilities were still using PCBs. The comparison population consisted of men and women residing in the City of Glens Falls, NY for 25 years or more. Glens Falls is upriver from the study villages, and environmental sampling data indicates that it was not affected by the capacitor plants' PCB pollution. The comparison population was frequency matched to the study population for age and gender.

Several sources were used to enumerate a pool of potential participants from the study and comparison areas. Initially, we employed an on-line telephone directory search engine; later we obtained a digital database from InfoUSA. Computerized records from the New York State Department of Motor Vehicles were used to obtain the birth date and gender for each person on the lists. With source populations identified, we randomly selected persons for participation. To avoid confounding with occupational exposures to PCBs, anyone who had worked for one year or more at the capacitor plants or any other job that entailed exposure to PCBs was excluded.

Interviews were conducted in the years 2000 through 2002. The dietary history consisted of a detailed report of the participant's consumption of Hudson River fish, including the species, frequency, and duration of consumption. Although emphasis was placed on fish obtained from the Hudson River, all fresh bodies of water in New York were assessed. The participants were asked to report their fish intake over four periods of time: the 1970s or earlier, 1980s, 1990s, and in the past year.

To simplify the dietary exposure assessment, we focused on fish consumed from a 25 mile stretch of the upper Hudson River. The PCB concentrations in fish samples were averaged by decade and location for each of the seven species most frequently consumed by study participants. These average total PCB

concentrations were then multiplied by the yearly consumption rate and the number of years consumed for each of the four time periods and summed to estimate cumulative lifetime exposure to PCBs from the consumption of Hudson River fish.

We used residential proximity to the Hudson River at the time of interview as an indicator of potential exposure to PCBs via inhalation for persons from the study area. Distance was calculated from the geocoded addresses to the nearest point on the River. An 800 m cutpoint was used to categorize residences as being proximate to the River because it came closest to a median split. We also examined the potential impact of 19 PCB-contaminated hazardous waste sites in the study area. In addition to proximity, we evaluated how often each residential address was downwind of one or more of these PCB sites.

A 25 ml fasting sample of venous blood was collected in a red top evacuated glass tube without EDTA by nurses certified in standard phlebotomy techniques. The blood was centrifuged and the serum pipetted into a glass bottle with a Teflon-lined cap. The serum was then analyzed for the 30 congeners that typically constitute over 95% of the total PCB residue in human serum,[3] using dual capillary gas chromatography with micro-electron capture detection. Non-detectable concentrations were assigned to one half the detection limit of 0.02 ppb per congener. The 30 congeners were then summed to estimate total PCB. Cholesterol and triglycerides were assayed enzymatically so that the PCB concentrations could be expressed on both a wet weight and lipid basis.[4] In addition, 9 dioxin-like PCB congeners were measured in the serum of more than 90% of the study participants, and Toxic Equivalent Quantities (TEQs) were calculated.[5]

Multiple linear regression analysis was used to test for association between the potential environmental exposures and serum total PCB concentrations after controlling for potential confounders. Multiple regression analysis was also used to test for associations with congener-specific serum PCB concentrations for congeners that had detectable levels of PCBs for 50% or more of the samples and were found in local fish or outdoor air samples. A similar analysis was conducted for TEQs based on the serum concentrations of the nine measured dioxin-like congeners.

Results and Discussion

The final group for analysis included 253 participants, 133 in the study area and 120 in the comparison area. The response rates were 38% in the study area and 41% in the comparison area. Both groups were similar concerning age, gender, and most other background characteristics. Educational attainment, however, differed significantly with 65% of participants from the comparison area having more than a high school education versus 50% from the study area ($p < 0.05$).

Fifty-one participants (20%) reported eating at least one fish meal from the 25 mile stretch of the Hudson River that was the focus of the dietary exposure assessment. When consumption was limited to the seven most commonly consumed species, 48 persons (19%) reported eating fish from this stretch of the River during the 1970s or earlier, 14 (8%) during the 1980s, and 3 (2%) during the 1990s. Consumption was more prevalent among persons from the study area, with 24% ever reporting eating such fish compared to only 13% of persons from Glens Falls. Rates of Hudson River fish consumption were also higher in the study area, especially in the 1970's or earlier. Persons in the study area reported consuming a mean of 13.5 Hudson River fish meals annually in the 1970's or earlier, compared to a mean of 1.6 meals for the comparison area ($p < 0.05$). The finding that Hudson River fish consumption was most prevalent in the 1970's or earlier and then declined dramatically is most likely the result of the fishing ban and health advisories that were imposed on the Hudson River in 1976. In fact, 98% of the study participants stated that they were aware of the ban and advisories.

The mean total PCB concentration was 3.6 ppb (wet weight), with a standard deviation of 2.0 ppb. Thirty-nine participants (15%) had a total PCB level $\geq$ 5.0 ppb and 4 participants (2%) had a level $\geq$ 10 ppb. The median total PCB level was 3.2 ppb, with a maximum of 19.3 ppb. The six leading PCB congeners, based on the highest mean concentrations, were PCB-74, 118, 153, 138, 170, and 180. On average, these congeners accounted for approximately two-thirds of the total PCB in serum. Nine dioxin-like PCB congeners were measured in the serum of 232 participants. The mean PCB TEQ concentration was 34.2 ppt (lipid basis), and the median was 14.9 ppt.

Age, BMI, and cigarette smoking were the only background variables associated with serum total PCB concentration in the multiple regression analysis. Specifically, log serum PCB concentrations (lipid basis) increased with age ($\beta = 0.021$, $p < 0.001$) and BMI ($\beta = 0.010$, $p = 0.031$) and decreased with packs of cigarettes smoked in the past year ($\beta = - 0.014$, $p = 0.105$). Consequently, these variables were included in the final regression models. Other studies have also found that age is an important correlate[6], probably reflecting the greater cumulative exposure of older persons to PCBs and the long biological half-lives of these compounds. The findings of other studies in regard to BMI are mixed, with some investigations also reporting positive correlations[7] whereas others have found inverse associations[8] or no association[9]. BMI is a crude indicator of adiposity, and its relationship to circulating levels of PCBs and other organochlorine compounds is complex, depending on the timing of exposure, pharmacokinetics, age, and serum lipids.[10] A decrease in PCB body burden with smoking may reflect the impact of cytochrome P-450 enzymes such as CYP1A1 and CYP1A2, since they are induced by smoking[11] and are involved in the metabolism of PCBs.[12]

After adjusting for age, BMI, and smoking, there was no significant difference in the geometric mean serum concentration of total PCB between the study and comparison area (either wet weight or lipid basis). Regarding individual congeners, only PCB-99 and 118 showed a difference at $p < 0.10$, and both were higher in the comparison area. There also was no significant difference between the areas in geometric mean TEQ concentration. Given the similarity in total and congener-specific serum PCB concentrations between the study and comparison areas, the results do not support the hypothesis that current body burdens of PCBs among older, long-term residents of Fort Edward or Hudson Falls are greater than Glens Falls residents. Caution must be exercised in comparing serum PCB levels across studies given differences in analytical methods, time periods, and populations.[13] In general, however, the serum total PCB levels of both the study and comparison populations are similar to those of other populations with no unusual exposure to PCBs.[14]

The 48 persons who reported eating the seven species of Hudson River fish were divided into low and high groups according to their median estimated cumulative lifetime exposure to PCBs. The geometric mean serum PCB concentration after adjustment for age, BMI, and smoking for the group with the greatest cumulative lifetime exposure to PCBs from Hudson River fish was 553.6 ppb (lipid basis), compared with 469.9 ppb (lipid basis) for 197 persons who did not eat Hudson River fish ($p < 0.10$). The high exposure group also tended to have greater geometric mean serum concentrations for many individual congeners, with statistically significant differences apparent for PCB-170 and 180. There were no significant differences in mean TEQ concentration according to Hudson River fish consumption. Despite the low current consumption rate, the findings are generally consistent with those of other studies indicating that the ingestion of contaminated fish is a major source of exposure to PCBs.[1] The results also attest to the long biological half-lives of congeners such as PCB-170 and 180.[15]

Regarding residential PCB exposure, there were no significant differences in geometric mean serum PCB concentrations according to residence within 800 m of the River, either for total serum PCB or individual congeners, after adjustment for Hudson River fish consumption, age, BMI, and smoking. Similarly, we did not observe significant differences in adjusted geometric mean serum concentrations of total or congener-specific PCB by wind direction and residential proximity to PCB sites. There were also no differences by residential proximity or wind direction in adjusted geometric mean TEQ concentrations. These findings do not support the hypothesis that persons who live near the River or one of 19 PCB-contaminated waste sites in the study area have elevated serum PCB concentrations. The lack of significant differences by proximity and wind direction is consistent with the results of other studies suggesting persons living near local point sources such as hazardous waste sites do not have elevated PCB body burdens independent of other exposures such as diet and occupation.[16, 17]

The restriction of the study population to older, long term residents strengthened this study as it maximizes the potential for exposure since everyone from the study area lived there when the capacitor facilities were using PCBs. A concurrent comparison group matched on age and gender from another community upriver from the pollution is also a strength. Recall accuracy is a possible limitation, especially as it pertains to consumption 10 or more years ago. The positive correlation between fish consumption and serum PCB levels, including two persistent congeners found in Hudson River fish, however, helps to validate the dietary histories. Our test of the inhalation hypothesis depended on surrogates rather than direct air PCB

measurements. Although previous studies indicate that air levels are inversely related to distance from the Hudson River, [18] this approach may have introduced exposure misclassification. Both indoor and outdoor air samples were collected from the homes of participants as part of the project, and are currently being analyzed for PCBs. When the results are available, they will be correlated with the serum PCB data to identify associations.

Finally, it is important to note that the results of this study pertain only to the years 2000-2002. It is possible that differences in serum PCB concentrations between the study and comparison areas existed in the past, when levels of PCBs in the local environment were higher. This is particularly relevant for the lightly chlorinated congeners, since they are more easily metabolized and excreted. It is also likely that differences in serum PCB concentrations by Hudson River fish consumption were greater in the past than they are currently, since most of the consumption occurred in the 1970's or earlier.

In conclusion, the results suggest that, although some older long term residents of Fort Edward and Hudson Falls ate fish from the upper Hudson River in the past, their current rates of consumption are low. The ban and advisories issued by state environmental and health agencies appear to be responsible for this change. After adjustment for age, BMI, and smoking, geometric mean concentrations of PCBs in the serum of Fort Edward and Hudson Falls residents did not differ significantly from those for Glens Falls residents. In general, the serum PCB levels for both groups were similar to those reported in other studies of persons with no unusual PCB exposures. Despite low current consumption rates, serum PCB levels tended to increase with estimated cumulative lifetime exposure to PCBs from Hudson River fish consumption, attesting to the long biological half life of congeners such as PCB-170 and 180. No significant differences were found in geometric mean serum PCB concentrations according to residential proximity or wind direction, arguing against the hypothesis that airborne PCBs from the Hudson River or local PCB-containing sites are elevating body burdens in this area.

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