

## EXPOSURE TO AND HEALTH EFFECTS OF PCBs FROM HAZARDOUS WASTE

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## ABSTRACT

An epidemiologic study is underway of Mohawk women and their children to test the hypothesis that exposure to polychlorinated biphenyls (PCBs) from a nearby Superfund hazardous waste site elevates body burdens and adversely affects health. The first phase of the study ended in 1992. It focused on exposure assessment, emphasizing diet and nursing as pathways. Exposure and body burdens were respectively determined by measuring the amount of contaminated fish and wildlife consumed by the mother and by analyzing breast milk and urine for 68 PCB congeners. The second phase of the project will continue until 1995, and emphasizes prenatal recruitment and serum PCB testing. Breast milk is also being collected for the analysis of coplanar PCB, dioxins, and dibenzofurans. Air, soil, and other environmental samples are being obtained to assess the impact of other pathways in addition to diet, and cytochrome P-450 dependent liver enzyme activity is being monitored as a marker of early biologic effect. Health endpoints being studied include pregnancy outcomes such as birth weight, infant health conditions, and developmental milestones. The results will significantly enhance our understanding of how chemicals arising from hazardous waste bioconcentrate in and adversely affect adults and infants.

## INTRODUCTION

The focus of the study is the Mohawk Nation at Akwasasne, a Native American community of more than 10,000 persons. It comprises approximately 28,000 acres and is located along the St. Lawrence River in New York (USA), Ontario, and Quebec (Canada). Less than 100 feet to the west of Akwasasne and within 1,000 yards of several Mohawk homes is the Central Foundry Division of the General Motors Corporation (GM-CFD). The facility has been in operation since 1959 for die-casting molten aluminum into automotive parts. Until 1974, it used PCB-based hydraulic fluids, which leaked into the facility's waste water treatment system. PCB-contaminated sludge from this system was disposed of at several lagoons and landfills on the property. Analysis of sludge and soil have revealed PCB concentrations as great as 3 to 4%. The levels in groundwater samples collected from monitoring wells at the facility have been up to 1,200 ppb. Sediment levels up to 5,550 ppm

have been detected off-shore in the St. Lawrence River, and surface water in a nearby cove had a value of 15 ppb (RMT, 1986).

Two other point sources of PCBs have been discovered in the area. Reynolds Metals, Inc. operates an aluminum smelter along the St. Lawrence River about one mile upriver from Akwesasne. On-site sampling has indicated soil concentrations of PCBs as great as 1,327 ppm (Engineering Science, 1987). ALCOA also operates a similar facility about six miles upriver from Akwesasne. Environmental sampling near that site has demonstrated contamination of the Grasse River, a tributary of the St. Lawrence, with sediment concentrations of up to 370 ppm (Woodward Clyde Consultants, 1991). The source in each case is again believed to be leakage of PCB-containing hydraulic fluids. There is also evidence that PCBs have entered the food chain (Sloan and Jock, 1990; Skinner, 1992).

The pollution is a major concern of the Mohawk people, since their tradition and culture emphasize the interdependence of man and his environment and because many residents formerly depended on local fish, waterfowl, and mammals for food. To address the question of to what extent has the consumption of contaminated fish and game resulted in human exposure to PCBs, an epidemiologic study is underway of Mohawk women and their children. These subgroups were chosen as the target populations since fetuses and children are particularly vulnerable to the effects of toxicants (WHO, 1986).

The first phase of the project ended in 1992. It had six specific aims: 1) to estimate maternal PCB exposure through the ingestion of contaminated fish; 2) to correlate this estimate of maternal exposure to the concentrations in breast milk of 68 of the most commonly encountered PCB congeners; 3) to compare the Mohawk milk PCB concentrations with those observed in a rural control group of nursing Caucasian mothers; 4) to correlate an infant's post-natal exposure through breast milk to levels of PCBs in his or her urine; 5) to follow each mother-infant pair from birth to three months post-partum; and 6) to explore approaches for "fingerprinting" the three industrial facilities as point sources of PCB exposure by matching the congener patterns found in the human samples with those identified in contaminated fish, wildlife and environmental samples.

## METHODS

All Mohawk women who lived at Akwesasne and who gave birth between March 1, 1988 and March 31, 1992 were eligible to participate in the first phase of the study. Those who participated in our pilot project in 1986 and 1987 were also included. Potential participants were identified before they delivered or within one month after their child was born by project staff through the Outreach Department of the St. Regis Mohawk Health Services, the local Women and Infant Care (WIC) Program, private physicians and other contacts. All women willing to participate in the study were interviewed at home by project personnel two to four weeks post-partum. The interview included sociodemographic characteristics, height and weight, health conditions, use of medications, occupational, reproductive, and residential histories, cigarette smoking, alcohol consumption, drinking

water source, and diet.

After each interview was completed, project personnel instructed the mothers in the use of the Marshall 900 CP Kaneson breast pump/infant nurser. They were asked to provide at least 50 ml of breast milk, over a period of several days if necessary. Each mother also provided a 24 hour urine sample of at least 100 ml. In addition, she was given cloth diapers and lanoline as a lubricant, both specially prepared by the laboratory and chosen to be uncontaminated beforehand. She was asked to use them to obtain three samples of overnight urine without feces from her child for PCB analysis. Dr. Brian Bush of the Department of Environmental Health and Toxicology, State University of New York at Albany and the Wadsworth Center for Laboratories and Research, New York State Department of Health, performed the PCB analysis. His methods are published elsewhere (Bush et al, 1982, 1983).

Each Mohawk woman's dietary exposure to PCBs was estimated by combining her interview data with the results of the fish sampling that has been conducted by the New York State Department of Environmental Conservation as part of the Health Risk Assessment for the GM-CFD site (Sloan and Jock, 1990). This effort focused upon the five of the 22 species collected that are most frequently consumed by the Mohawks. Of the 12 sampling locations, those utilized most heavily by the Mohawks for fishing were selected, together with those located closest to the three local industrial facilities. A total of 149 extracts, representing all samples of each species from each location, were obtained from the contract laboratory. They were cleaned-up, pooled to form composite samples by species and location, and analyzed by Dr. Bush's laboratory for the same 68 PCB congeners as were the human samples.

#### PRELIMINARY RESULTS AND DISCUSSION

As of March 31, 1992, 97 Mohawk and 157 control mothers had participated. To date, the statistical analysis has focused upon the first three aims, and has included the 57 Mohawks and 109 controls who had participated through 1990.

Regarding dietary exposure, the data indicate that local fish consumption has declined significantly over time among the Mohawks. That is, the mothers reported on average of 2 local fish meals per month for the period more than one year before the index pregnancy, compared to less than 0.5 local fish meals per month during pregnancy ( $p < 0.001$ ). This decrease is probably related to the advisories that have been issued by Mohawk, state, and provincial agencies against the eating of any fish from that area of the St. Lawrence River by women of child-bearing age, and it attests to the concerns of the mothers about the potential health effects of environmental contamination at Akwesasne. However, over one-third still ate local fish at least once during pregnancy. Further health education efforts are necessary, together with suggestions for alternative protein sources.

After adjustment for potential confounding variables, Mohawk mothers who gave birth in 1986-1989 had a geometric mean total PCB concentration of 0.602 ppm (fat basis) in

their breast milk, compared to 0.375 ppm for women in the comparison group who delivered during the same period ( $p = 0.009$ ). These Mohawk women also had significantly higher geometric mean concentrations of nine PCB congeners, including several mono- and di-ortho-chloro-substituted derivatives of the highly toxic coplanar PCBs (McFarland and Clark, 1987). Beginning with mothers who participated in 1990, however, Mohawks did not have significantly elevated levels on average relative to the comparison group (0.352 and 0.404 ppm, respectively).

This time-dependent association resulted from the fact that the Mohawk women showed a significant decline in their milk PCB concentrations according to when they participated ( $p = 0.005$ ), while the controls remained relatively stable over time. These differences in milk total PCB paralleled similar differences in fish consumption, with Mohawk women who participated in 1990 having eaten less local fish relative to their counterparts in 1986-89, especially during pregnancy (annual means of 8.5 local fish meals for 1986-89 participants versus 3.3 for 1990 participants ( $p = 0.088$ )). Mohawks who participated in 1990 were also more likely to remove the skin and fat from any fish that they did consume.

Among women who gave birth from 1986 through 1989, Mohawk mothers with the greatest estimated lifetime exposure to PCBs from the consumption of local fish had an adjusted geometric mean milk total PCB concentration of 0.691 ppm, compared with 0.603 ppm for those with less lifetime exposure, 0.397 ppm for Mohawk women who never ate any local fish, and 0.372 ppm for the control group ( $p = 0.009$  for test of linear trend). This was especially true for those congeners found in fish taken near GM-CFD. These differences, however, were no longer apparent among women who gave birth in 1990. This finding is consistent with the notion that, due to their dietary practices, women who participated late in the study period have reduced their exposures.

In addition to fish consumption, residential exposures were also examined. The results indicated that milk total PCB levels were positively associated with duration of residence on Cornwall Island. Mohawk mothers who had lived there for at least six of the past 10 years had an adjusted geometric mean concentration of 0.606 ppm, versus 0.521 ppm for those with 1 to 5 years of residence, 0.352 ppm for Mohawk women who did not live there, and 0.394 ppm for the controls (test for linear trend  $p = 0.042$ ). This difference was unrelated to fish consumption and was persistent through 1990. The reason is unknown, but the PCB congener pattern in the breast milk of Cornwall Island residents suggests multiple exposures. Such results are consistent with the fact that Cornwall Island is located in the middle of the St. Lawrence River, off-shore from the GM-CFD and Reynolds facilities on the American side and the city of Cornwall on the Canadian portion of the Reserve. In other words, it is at the confluence of several known or potential point sources of PCBs.

#### CURRENT ACTIVITIES

The statistical analyses of data relevant to our three other specific aims are ongoing,

and should be completed by the end of 1994. They include an evaluation of the urinary PCB assay and its utility in assessing human exposure, especially among the infants. To assess change in body burdens over time, we are comparing the breast milk levels of the same women at one and three months post-partum. We are also "fingerprinting" the waste site as a point source of PCB contamination by comparing the congener pattern of Aroclor 1248, the commercial mixture used at the General Motors facility, with those found in fish collected near the site and in the breast milk samples. This task involves three dimensional bar charts as well as more formal approaches such as cluster analysis and summary score functions.

Even after these analyses are completed, a number of important questions will remain unanswered. For example, maternal consumption of local fish and game has been the major pathway investigated to date. It is possible, however, that routes other than ingestion and sources other than fish and game are involved, especially among Mohawk women who reside on Cornwall Island. The extent to which infants are being exposed pre-natally is unclear. Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) must also be considered, since they have been related to the waste site and neighboring industrial facilities. Finally, the biologic effects of these exposures in this population are unknown.

The second phase of the project will help address these issues. It began in 1992, and will continue until 1995. It has the following goals:

- 1) To estimate maternal exposure to 68 PCB and 34 PCDD/F congeners from hazardous waste through inhalation, ingestion, and dermal contact. Concentrations of PCB and PCDD/F congeners in the air, drinking water, and soil, together with fish and wildlife contaminant data, will be related to personal behavior patterns.
- 2) To correlate these measures of maternal exposure to the concentrations of the same PCB congeners in serum and urine, and, in breast milk (if nursing), to the same PCDD/F congeners, in addition to 12 coplanar PCBs congeners or their mono-ortho-substituted derivatives. Exposure from all relevant routes and sources will be combined to estimate total cumulative dose and correlated with levels in bodily fluids.
- 3) To assess the effects of pre- and post-natal exposure on infant urinary PCB concentrations. Cord serum PCB and, if nursing, breast milk PCB congener levels will be related to infant urine levels. Breast- and bottle-fed infants will also be compared regarding these measures.
- 4) To investigate change in pollutant levels over time. Each mother-infant pair will be followed to 6 months post-partum.
- 5) To test the ability of PCB and PCDD/F congeners induce cytochrome P-450 dependent liver enzymes in humans. A breath test employing labeled carbon dioxide will be used to monitor P-450IA2 dependent caffeine N-demethylase activity (Lambert et al, 1990), and this measure will be correlated with PCB and PCDD/F levels in Mohawk mothers.

6) To determine the impact of exposure on the health status of infants by relating maternal and infant PCB levels to pregnancy outcomes such as birth weight, birth length, and gestational age, the prevalence of minor and major infant health conditions such as rashes or pneumonia, and the age at which the infant achieves developmental milestones such as crawling and sitting-up.

Data from both phases of the project will enhance our understanding of how contaminants arising from hazardous waste are absorbed and excreted by human populations, and assist in evaluating the risk of adverse health effects.

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