

RESEARCH ON TOXIC CHEMICALS IN THE UNITED STATES FROM THE GREAT LAKES BASIN: DEFINING STUDIES TO HELP ENSURE HEALTHY PEOPLE IN EVERY STAGE OF LIFE

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Introduction

The Great Lakes is the largest system of fresh surface water on earth, comprising roughly 18% of the world supply. Approximately 12% of the U.S. population and 25% of the Canadian population live in the region. In 1985, 11 of the most persistent and widespread toxic substances were identified as “critical Great Lakes pollutants” by the International Joint Commission (IJC). The critical pollutants are: polychlorinated biphenyls (PCBs), dichlorodiphenyl trichloroethane (DDT), dieldrin, toxaphene, mirex, methylmercury, benzo[a]pyrene (a member of a class of substances known as polycyclic aromatic hydrocarbons [PAHs], hexachlorobenzene (HCB), furans, dioxins and alkylated lead.¹

Because of the persistence and ubiquitous presence of these chemicals in the environment, toxic effects in the Great Lakes wildlife have been demonstrated and results from early epidemiologic investigations suggest the potential for adverse human health effects, i.e., developmental, neurologic, and immunologic.² Given the implications of the association between pollutants in the Great Lakes and the potential for adverse human health outcomes, the U.S. Congress amended the Great Lakes Critical Programs Act in 1990 to investigate this human health concern. In 1992, the Agency for Toxic Substances and Disease Registry received funding to initiate the Great Lakes Human Health Effects Research Program (GLHHERP).

Methods

The GLHHERP was designed to characterize exposure and investigate the potential for short and long-term adverse health effects from exposure to PTSs in the basin. The identified potential health effects investigated included behavioral, reproductive, developmental, neurologic, endocrinologic, and immunologic measures. Populations studied included American Indians, African Americans, pregnant women, nursing infants of mother who consumed contaminated fish, children and the elderly. This research was conducted by Great Lakes state health departments, academic institutions, and federally recognized tribal governments.

Health Effects

Maternal Fish Consumption, Mercury Levels, and Risk of Preterm Delivery

Researchers from Michigan State University established the Pregnancy Outcomes and Community Health (POUCH) study. Women were enrolled in the 15th to 27th week of pregnancy from 52 prenatal clinics in five Michigan communities. At enrollment, information was gathered on amount and category of fish consumed during the current pregnancy, and a hair sample was obtained. A segment of hair closest to the scalp, approximating exposure during pregnancy, was assessed for total mercury levels in 1,024 POUCH cohort women.

Results: Mercury levels ranged from 0.01 to 2.50 ug/g (mean =0.29ug/g median =0.23 ug/g). Total fish consumption and consumption of canned fish, bought fish, and sport-caught fish were positively associated with mercury levels in hair.

Compared with women delivering at term, women who delivered before 35 weeks gestation were more likely to have hair mercury levels at or above the 90th percentile (≥ 0.55 g/g), even after adjusting for maternal characteristics and fish consumption (adjusted odds ratio = 3.0; 95% confidence interval, 1.3-6.7

Conclusion: This is the first large, community-based study to examine risk of preterm birth in relation to mercury levels among women with low to moderate exposure. Additional studies are needed to see whether these findings will be replicated in other settings. ³

Polybrominated biphenyls, Polychlorinated biphenyls, Body Weight, and Incidence of Adult-onset Diabetes Mellitus.

Background: Prior studies have reported an increased risk of diabetes related to polychlorinated biphenyl (PCB) exposure. No study has yet investigated whether polybrominated biphenyls (PBBs), which are similar in chemical structure, increase the incidence of diabetes.

Methods: Researchers from the University of Michigan used the Michigan PBB cohort which was established in 1976 and surveyed again in 1991-1993 and in 2001. PBB and PCB serum levels were measured from the blood collected at enrollment. To determine the incidence of adult-onset diabetes, they analyzed cohort members with our diabetes at enrollment, ages 20 years and older, with known PBB and PCB levels, who participated in at least 1 follow-up survey (n = 1384). The researchers determined the incidence density ratio (IDR) of diabetes for different serum levels of PBB and PCB, controlling for age, body mass index, smoking, and alcohol consumption at enrollment.

Results: Analyzing 25 years of follow-up data, the researchers did not find that higher PBB serum levels were a risk factor for the incidence of diabetes mellitus. However, in women, but not in men, higher PCB serum levels were associated with increased incidence of diabetes (IDR =2.33: 95% confidence interval =1.25-4.34 in the highest PCB group compared with the lowest). In both men and women, overweight and obesity increased the diabetes incidence.

Conclusions: The researchers found no association between PBB serum levels and diabetes incidence. In women, there was a positive linear association of diabetes incidence with PCB serum levels at enrollment. This finding is in agreement with 2 prior studies indicating a higher relative risk of diabetes in PCB-exposed women. ⁴

Birth Defects Risk Associated with Maternal Sport Fish consumption: Potential Effect Modification by Sex of Offspring

Contaminated sport fish consumption may result in exposure to various reproductive and developmental toxicants, including pesticides and other suspected endocrine disruptors. The Research Foundation of State University of New York at Buffalo investigated the relationship between maternal sport fish meals and the risk of major birth defects among infants born to members of the New York State (NYS) Angler Cohort between 1986 and 1991 (n = 2237 births). Birth defects (n = 125 cases) were ascertained from both newborn medical records and the NYS Congenital Malformations Registry.

For sport fish meals eaten during pregnancy, the odds ratio (OR) for all major malformations combined was slightly elevated for ≤ 1 meal/month (OR = 1.26, 95% confidence interval (CI): 0.84,

1.89) and ≥ 2 meals/month (OR =1.51, CI =0.74, 3.09), with no meals during pregnancy as the reference category. Higher ORs were consistently observed among male offspring compared with females. For > 2 meals/month, the risk for males was significantly elevated (males: OR = 3.01, CI: 1.2, 7.5; females: OR = 0.73, CI: 0.2, 2.4).

Exposure during pregnancy and effect modification by infants sex could be important considerations for future studies of birth outcomes associated with endocrine disruptors.⁵

Maternal Concentration of Polychlorinated Biphenyls and Dichlorodiphenyl Dichloroethylene and Birth Weight in Michigan Fish Eaters: Cohort Study

Studies on maternal exposure to polychlorinated biphenyls (PCBs) reported inconsistent findings regarding birth weight: some studies showed no effect, some reported decreased birth weight and one study found an increase in weight. These studies used different markers of exposure such as questionnaire data on fish consumption and maternal serum PCB levels. Additionally, maternal exposures, such as dichlorodiphenyl-dichloroethylene (DDE), which are related to PCB exposure and may interfere with the PCB effect, were rarely taken into account.

Methods: Between 1973 and 1991, Michigan State University and the Michigan Department of Health conducted three surveys to assess PCB and DDE serum concentration in Michigan anglers. Through telephone interviews with parents, they gathered information on birth characteristics of their children, focusing on deliveries that occurred after 1968. The maternal DDE and PCB serum concentrations were categorized as follows: 0 - <5 microgram/L, 5 - <15 microgram/Liter, and 15 - <25 microgram/Liter, and ≥ 25 microgram/ Liter.

Results: The researchers identified one hundred and sixty eight children who were born after 1968 and had maternal exposure information. They found a reduced birth weight for the children of mothers who had a PCB concentration of ≥ 25 microgram/L (adjusted birth weight = 2,958gram, $p = 0.022$). This group, however, was comprised of only seven observations. The association was not reduced when the researchers excluded preterm deliveries. The birth weight of children was increased in women with higher DDE concentrations when controlling for PCBs.

Conclusion: The researchers found no significant increase in birth weight associated with maternal DDE exposure, but a significant reduction in birth weight of approximately 500 grams in children with PCB levels of $> 25\mu\text{g/Liter}$. The researchers indicated that their results contribute to the body of evidence that high maternal serum PCB concentration may reduce the birth weight in children. However, only a small proportion of mothers may actually be exposed to PCB concentrations ≥ 25 microgram/Liter (Karmaus and Zhu, 2004).⁶

Decreased Sex Ratio Following Maternal Exposure to Polychlorinated biphenyls from Contaminated Great Lakes Sport Caught Fish: A Retrospective Cohort Study

Background: Fish from the Great Lakes are contaminated with polychlorinated biphenyls, which have been found to have several adverse reproductive effects. Several environmental contaminants have been found to alter the sex ratio of offspring at birth, but the evidence of such an effect of polychlorinated biphenyls (PCB) has been inconsistent.

Methods: Researchers from Wisconsin Division of Public Health examined parental serum polychlorinated biphenyl concentration in relation to the sex ratio of 173 children of mothers and 208 children of fathers from the Great Lakes region of the United States. The researchers calculated odds ratios for a male child, adjusting for the year of birth of the child, maternal and paternal age, the mother's parity at the child's, and whether the child had an older brother.

Results: Mothers who had serum PCB levels of 4.7 parts per billion (ppb) were less likely to have a male child than mothers with the lowest serum level of 0.7 ppb. The adjusted odds ratio for having a male child among mothers in the highest quintile of serum polychlorinated biphenyl was 0.18 (95% CI: 0.06 -0.59) compared to mothers in the lowest quintile. Treating exposure as a continuous variable, the adjusted odds ratio for a male child was 0.54 % increase in the natural log of maternal serum polychlorinated biphenyl concentration (95% CI: 0.33-0.89). There was little evidence of an association with paternal exposure (Weisskopf et al. 2003).⁷

Discussion

These research findings in the area of health effects are of public health concern. The at-risk populations identified in our program are at risk because of elevated exposures as well as possibly intrinsic physiologic sensitivity. Nursing infants, subsistence and sport anglers, as well as the elderly, are among these at-risk groups because of their elevated exposures. It is further recognized that the body burdens of fish eaters are 2 to 8 times higher than the general US population and that nursing infants may experience exposure rates anywhere from 40 to 50 times that of the general population.

Health education can be especially valuable in mitigating potential effects and informing individuals who may be at risk, e.g., pregnant women. There is also the need to develop strategies for prudent public health interventions and new risk communication tools that are intended to reduce human exposures. Finally, we can not lose sight of the fact that fish provide a diet high in protein and low in saturated fats, and studies have suggested that eating fish is beneficial to one's health.

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