Assessing the Health Status of Vulnerable Populations from Exposure to Persistent Toxic Substances in the U.S. Great Lakes

Heraline Hicks[1], Annette Ashizawa[2], Christophter T. De Rosa[2]

[1]Atsdr
[2]Colleague

Introduction

The Great Lakes is the largest system of fresh surface water on earth, comprising roughly 18 % of the world supply. Approximately 10% of the U.S. population and 25% of the Canadian population live in the region. For more than 200 years, the Great Lakes has been used as a resource for industry, agriculture, shipping, and recreation. 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]

Despite declining levels of toxic substances in the Great Lakes basin over past years, the presence of persistent toxic substances (PTSs) in the basin remains a major concern. In the United States, about 80,000 commercial and industrial compounds are now in use. More than 30,000 are produced or used in the Great Lakes basin. Because of the persistence and ubiquitous presence of these chemicals in the environment, toxic effects in 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 is designed to characterize exposure and investigate the potential for short- and long-term adverse health effects from exposure to PTSs via consumption of contaminated Great Lakes fish. The program focused on the “eleven critical Great Lakes pollutants” identified by the IJC as well as other chemicals of concern, i.e. cadmium and arsenic. The identified potential health effects to be investigated included behavioral, reproductive, developmental, neurologic, endocrinologic, and immunologic measures. Several human populations were also identified for study who may be at particular risk of exposure to Great Lakes pollutants via fish consumption. They include subsistence fish anglers, American Indians, African Americans, pregnant women, fetuses, nursing infants of mothers who consume contaminated Great Lakes sport fish (GLSF), young children, the elderly, and the urban poor. These criteria were published in a U.S. Federal Register Notice announcing a call for research grant applications to Great Lakes states health departments, academic institutions, and federally recognized tribal governments. Ten research grants were funded to implement this research program.

Results and Discussion

Some of the key research findings from the Great Lakes program will be briefly described for three areas - sociodemographics, exposure, and health effects. These findings include the following:

Sociodemographics

- A survey of adult residents of the eight Great Lakes states estimated that 4.7 million people consumed Great Lakes sport fish in a given year; 43.9% of the respondents were women. [3]
- Fifty percent of respondents to the survey who had eaten Great Lakes sport fish were aware of the health advisory for fish, and awareness differed significantly by race, sex, educational level, fish consumption, and state of residence. [3]
- Eighty percent of minorities who had eaten Great Lakes sport fish were unaware of the fish advisory, and awareness was especially low among women. [3]

Exposure

- Levels of some contaminants in Great Lakes sport fish are above the advisory limits set by the state and federal government. [4]
- Sport fisheaters consume on average 2 to 3 times more fish than the general U.S. population. Body burden levels of some PTSs in vulnerable populations are 2 to 8 times higher than those of the general U.S. population. [4]
- A significant trend of increasing body burden is associated with increased fish consumption. [4]
- Long term consumption of fish, even at low levels, contributes significantly to body burden levels.
- Maternal consumption of Lake Ontario Great Lakes fish increases the risk of prenatal exposure to the most heavily chlorinated PCBs. [6]

Health Effects

- Conception rate and the incidence of a live birth are lower in some women who are fish consumers. [4]
- Reproductive function may be disrupted by exposure to PTSs. Significant menstrual cycle reductions were indicated in women who reported consuming more than 1 meal per month of contaminated GLSF. [4]

The Oswego Newborn and Infant Development Study

In this study ATSDR

- Observed neurobehavioral and developmental deficits in newborns (12 to 24 hours after birth and again 25 to 48 hours after birth) of

mothers who consumed approximately 2.3 meals per month of contaminated Lake Ontario fish. [4]
Assessed the relation between prenatal exposure to PCBs and performance on the Neonatal Behavioral Assessment Scale (NBAS) was assessed. The results indicated significant relation between the most highly chlorinated PCBs and performance impairment on the habituation and autonomic tests of the NBAS at 25 - 48 hours after birth. No significant relation was found between PCBs of lesser chlorination, DDE, hexachlorobenzene, mirex, lead, or methylmercury on any NBAS performance test. [7]
Assessed the relation between prenatal exposure to PCBs and performance on the Fagan Test of Infant Intelligence (FTII) was assessed at 6 months and again at 12 months. The results indicated a significant relation between exposure to PCBs and poor performance on the FTII. No significant relation was found between exposure to dichlorodiphenyl dichloroethene (DDE) or methylmercury on any tests of the FTII. [8]
Assessed the children were again at 38 months and again at 54 months using the McCarthy Scales of Children's Abilities. Negative associations between prenatal methylmercury (MeHg) exposure and McCarthy performance were found in children with high levels of prenatal PCB exposure at 38 months. No relation between PCBs and MeHg and McCarthy performance was observed when the children were reassessed at 54 month.[9]

- Found that PCBs and DDE were highly elevated in an adult fisheating cohort. Exposure to PCBs, not DDE, was associated with lower scores on several measures of memory and learning. [10]
- Determined that serum PCB levels and consumption of Great Lakes fish were significantly associated with lower levels of thyroxine (T_4) in women and men. In contrast, fish consumption, but not PCB serum levels, was significantly and inversely associated with triiodothyronine (T_3) in men.[11]
- Observed that parents exposed to PCBs and DDE had a higher than expected proportion of male children than female children if the father had elevated PCB levels. [12]
- Observed that mothers who consumed 2 or more fish meals per month, the risk of their male child having a birth defect was significantly elevated (males: OR = 3.01, in comparison to female children: OR = .73). [13]

These research findings in the areas of exposure, sociodemographics, and especially 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. For example, the developing fetus is exquisitely sensitive to the effects of these chemicals during certain "windows" of development. 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 fisheaters are 2 to 8 times higher than in the general population and that nursing infants may experience exposure rates anywhere from 40 to 50 times that of the general population.

The reports of neurodevelopmental deficits and reproductive effects are especially compelling. Although some describe the observed neurodevelopmental effects as subtle, they can have profound implications for the affected populations . The public health case for action is based on a shift in the distribution curve of a measure of functional capacity like IQ. If the population as a whole is affected, the proportion of the population that falls into the gifted and disabled categories is significantly altered. Responsible and prudent public health practice cannot wait for irrefutable scientific evidence to amass before preventive measures are taken. Further, there is a need to improve the effectiveness of fish consumption advisories. Data indicate that people who are most at risk are the least informed about fish advisories. 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 cannot lose sight of the fact that the benefits from fish consumption should be considered when evaluating the health implications of fish consumption. Fish provide a diet high in protein and low in saturated fats, and recent studies suggest that eating fish is beneficial to one's health.

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