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# Maternal exposure to Great Lakes sport-caught fish and dichlorodiphenyl dichloroethylene, but not polychlorinated biphenyls, is associated with reduced birth weight

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**Abstract**

Fish consumption may be beneficial for a developing human fetus, but fish may also contain contaminants that could be detrimental. Great Lakes sport-caught fish (GLSCF) are contaminated with polychlorinated biphenyls (PCBs) and dichlorodiphenyl dichloroethylene (DDE), but the effects of these contaminants on birth outcome are not clear. To distinguish potential contaminant effects, we examined (1) whether the decrease over time in contaminant levels in GLSCF is paralleled by an increase in birth weight of children of GLSCF-consuming mothers and (2) the relation between maternal serum concentrations of these contaminants and birth weight. Mothers ($n = 511$) were interviewed from 1993 to 1995, and maternal serum was collected from 1994 to 1995 ($n = 143$). Potential confounders considered were child gender, maternal age at delivery, maternal prepregnancy body mass index, maternal cigarette and alcohol use during pregnancy, maternal education level, maternal parity, and maternal breastfeeding. Children born during 1970–1977, 1978–1984, and 1985–1993 to mothers who ate more than 116 meals of GLSCF before pregnancy were, on average, 164 g lighter, 46 g heavier, and 134 g heavier, respectively, than children of mothers who ate no GLSCF before pregnancy ($P$ trend = 0.05). GLSCF-consuming mothers had higher serum PCB and DDE concentrations, but only increased DDE was associated with lower birth weight. The data suggest that fetal DDE exposure (as indicated by maternal serum DDE concentration) may decrease birth weight and that decreased birth weight effects associated with GLSCF consumption have decreased over time.


*Keywords:* Fishes; Polychlorinated biphenyls; Dichlorodiphenyldichloroethylene; Newborn infant; Birth weight

## 1. Introduction

There is increasing evidence that fish consumption—a good source of protein and n-3 fatty acids—is beneficial for fetal growth and length of gestation during pregnancy (Olsen, 1993; Olsen et al., 2000; Olsen and Secher, 2002). On the other hand, fish may contain contaminants that could be detrimental to the fetus. In the Great Lakes, the bioaccumulation of polychlorinated biphenyls (PCBs) and dichlorodiphenyl dichloroethylene (DDE) in the body fat of fish, particularly the larger, predator species prized by sport-fishers, has been well documented (Cordle et al., 1982; Newsome and Andrews, 1993; USEPA, 1993). Some of the highest levels of PCBs found in humans are among fish consumers. Fish is also a route of exposure to DDE although there are also many other sources of high environmental exposure to DDE (Fiore et al., 1989; Hovinga et al., 1993; Anderson et al., 1998; Hanrahan et al., 1999b). PCBs and DDE comprise the bulk of organochlorine (OC) residues found in human tissues (Longnecker et al., 1997). PCBs were banned in the

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United States in 1977, however, and concentrations in Great Lakes fish have been declining since that time, with the greatest drops (about 25% drop in chubs and 30% in lake trout) found around 1977 (USEPA, 1993). Dichlorodiphenyltrichloroethane (DDT)—the parent compound of DDE—was banned in 1972, and DDE concentrations have been declining since the early 1970s also (ATSDR, 2001). In addition, health advisories concerning fish consumption and preparation have been disseminated since the late 1970s to help reduce human exposure to these contaminants in fish.

The potential toxicity of PCBs was first recognized following incidents in Japan in 1968 and Taiwan in 1979 when rice oil used for cooking was contaminated by heat-degraded PCBs during the manufacturing process (Chen et al., 1985; Hsu et al., 1985; Masuda et al., 1985; Rogan et al., 1988; Yen et al., 1989). These incidents in addition to both human occupational exposure studies (Taylor et al., 1984, 1989) and other animal studies (Allen et al., 1974, 1979, 1980; Allen and Barsotti, 1976; Barsotti et al., 1976; Brezner et al., 1984; Peterson et al., 1993; Brouwer et al., 1995) have led to PCBs being implicated as reproductive toxins. Toxic effects of DDT and DDE were widely recognized in the 1960s and 1970s in relation to avian eggshell thinning, and other adverse reproductive effects in birds have been reported since that time (ATSDR, 2001).

Effects of chronic environmental exposure to low doses of PCBs and DDE are unclear. Both case-control (O'Leary et al., 1970; Procianoy and Schvartsman, 1981; Saxena et al., 1981; Wassermann et al., 1982; Berkowitz et al., 1996) and cohort (Rogan et al., 1986b; Longnecker et al., 2001) studies have reached different conclusions on whether DDE is associated with reductions in birth weight or gestational length. Investigations into the effects on birth weight and gestational period of exposure to low-level PCBs in the environment have also had equivocal results (Fein et al., 1984; Rogan et al., 1986b; Dar et al., 1992; Rylander et al., 1995, 1996, 1998; Patandin et al., 1998; Vartiainen et al., 1998; Grandjean et al., 2001). The highest body burdens of PCBs, however, are found among fish consumers, and some of these studies did not focus on exposure via fish consumption. Thus, some discrepancy may arise because the body burdens of PCBs found in some studies may not have been high enough. Even among studies that consider fish consumption, however, results have been equivocal (Fein et al., 1984; Dar et al., 1992; Rylander et al., 1995, 1996, 1998; Vartiainen et al., 1998; Grandjean et al., 2001), although this may be in part because of confounding by the beneficial effects of fish.

We took two approaches to examining whether fetal exposure to PCBs and DDE by way of maternal Great Lakes sport-caught fish (GLSCF) consumption is a risk factor for decreased birth weight. The first approach was to examine whether the effect of maternal GLSCF consumption on birth weight differed between children born in the period 1970–1977 and those born after that time. If maternal exposure to PCBs or DDE reduces birth weight, then the reduction in birth weight associated with maternal consumption of GLSCF should be more pronounced for children born before the time when production of PCBs and DDE was banned than for those born after that time. This is because the contaminant level in the fish was greater in the earlier period, and thus exposure of the mother was greater for the same amount of fish consumed. The second approach was to examine whether maternal serum PCB and DDE concentration was associated with lower birth weight in a subset of our cohort who donated blood for analysis.

## 2. Methods

### 2.1. Study sample

Under the Congressional Great Lakes Critical Programs Act of 1990, the health departments of Wisconsin, Illinois, Indiana, Ohio, and Michigan formed a consortium to assess health risks associated with PCB and DDE exposure from consumption of contaminated GLSCF. This study is part of the work of that consortium and the recruitment and questionnaire methods are described in detail elsewhere (Anderson et al., 1996; Hanrahan et al., 1999b). In brief, we attempted to contact two different populations: licensed sport-fishing charter boat captains from the consortium states whom we presumed to be frequent GLSCF consumers (the Captains cohort) and a random sample of the general population who were infrequent fish consumers (the infrequent consumers cohort) to include more persons with low GLSCF consumption. The selection criterion for the Captains cohort was that they were licensed in 1992 in one of the consortium states. The inclusion criteria for the infrequent consumers cohort were that they had eaten no GLSCF in the year before the survey and not more than five meals in any year since 1970. Between 1993 and 1995 we interviewed by telephone charter boat Captains and their spouses ($n = 1863$ households; approximately 83% response rate). We used random digit dialing with matching to the Captains cohort by age (individual matching $\pm 3$ years) and region (first six digits of the telephone exchange) to contact the general population ($n = 1274$ households; approximately 65% response rate). Birth certificates were obtained to validate the existence of self-reported children. If either the birth certificate or the mother indicated that a child was not a singleton birth, that child was excluded from analysis. So that we could determine parity, we considered only mothers for whom firstborn children could be identified. There were 609