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COMMENTARY

Persistent Organic Pollutants in Children

Commentary on the article by Karmaus *et al.* on page 331

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Why are the determinants of levels of persistent, stable, halogenated ring compounds in children of interest? Is exposure to commonly encountered levels of organochlorines, also called persistent organic pollutants (POP), harmful?

Data exist that support such effects (1). Examples include associations with altered neurodevelopment (2), thyroid economy (3), and estrogen and immune function (4, 5). Yet for all such associations, human evidence regarding causality at low doses remains equivocal at best, owing to inconsistent results, inadequate replication, and other questions (1). In the laboratory, the neurotoxic, immunotoxic, and hormonal activity of many of these compounds has been established (6–8), and the issue has been whether effects occur at background exposure levels, not whether the compounds are toxic.

Karmaus *et al.* found that the blood level of several POP in children was determined more by having been breast-fed than any other factor considered. In previous investigations of determinants of POP levels among children, the contribution of having been breast-fed has been consistently identified (Table) (9–13). In the two previous studies in which the relative importance of various determinants was evaluated (11, 12), breast-feeding was also found to be the most important factor.

Throughout the world, human breast milk is contaminated with POP (14). The first report of DDT in breast milk appeared in 1951 (15), and a large literature shows that uncontaminated breast milk has not been found since then. Despite this, the World Health Organization and the American Academy of Pediatrics have weighed the benefits of breast-feeding against any possible risks incurred by exposure to these compounds in breast milk, and have consistently supported breast-feeding (16–18). The support for breast-feeding, despite the possibility that polychlorinated biphenyls (PCB) alter neurodevelopment, is justified. Nearly all of the studies that show effects from prenatal exposure have looked for effects from the greater exposure that comes through breast milk and have not found an association (19).

One aspect of the Karmaus *et al.* study that makes it especially useful is that it was relatively large and the subjects were older compared with previous studies among children (Table), where data had been sparse. In addition, their investigation of potential determinants was unusually thorough.

Besides breast-feeding, another predictor of POP levels identified by Karmaus *et al.* was body mass index (BMI). Levels of POP declined with increasing BMI. To our knowledge, only one other report has investigated this association among children, in a study of 12 hospitalized subjects from Kazakhstan (20). Among those children, levels of POP also decreased with increasing BMI. Karmaus and colleagues suggested that the inverse relation of levels with BMI among children was due to dilution, which is sensible given the long half-life of these compounds *in vivo*. Assuming the inverse relation of levels with BMI among children is generally true, it must weaken with age. In adults, when an association between POP and BMI is present, POP levels increase with BMI (21–25); this association is independent of serum lipid levels (21, 25). While a positive association has been reported most often in older adults, Schade and Heinzow (21) found it even among women who had just delivered. An inverse relation of POP level with BMI may occur while the child's body burden still reflects the contribution of breast-feeding. As the contribution of the subject's later diet assumes greater importance in determining the body burden, the BMI may be positively

Table 1. *Studies that show having been breast fed is associated with higher levels of persistent organic pollutants in children*

Author	Publication year	*n*	Age range (y)	Compounds related to breastfeeding
Kuwabara et al. (9)	1978	39	1–11	PCB
Niessen et al. (10)	1984	41	0–2	DDT, PCB, HCH, HCB
Jacobson et al. (11)	1989	285	4	DDT, PCB, PBB
Schantz et al. (12)	1994	38	6–12	DDT, PCB
Lanting et al. (13)	1998	211	3	PCB
Karmaus et al.	2001	337	7–10	DDE, PCB, HCH, HCB

Abbreviations: PCB, polychlorinated biphenyls; HCH, hexachlorocyclohexane; HCB, hexachlorobenzene; PBB, polybrominated biphenyl; DDE, dichlorodiphenyldichloroethylene.

correlated because it either accompanies a diet high in POP-rich foods or because greater BMI may reflect that a greater mass of food has been "filtered" through the subject.

Karmaus *et al.* hypothesized that with higher birth order, a child's POP levels would decrease because the mother would have lessened her POP burden by previous breast-feeding (21). Few children in their study had a birth order of 3 or more, limiting their statistical power to test the hypothesis. Even though their data did not support their hypothesis, studies of groups with a larger range of birth order and for which there are data on breast-feeding in previous pregnancies might be able to demonstrate the phenomenon.

How might we minimize children's exposure to POP? Levels of many of these compounds in humans have generally been declining (14, 21), because of decreased production and regulations in response to health and environmental concerns. Advisories to restrict consumption of especially contaminated fish are already in place throughout the United States and eastern Canada (26). On an individual level, women could reduce their exposure before entering childbearing years by reducing intake of foods that contribute most to POP intake (27). The foods that contribute most to intake of PCB, for example, are dairy, meats, and in some populations, fish (28). Reducing intake of such foods may not be a simple task in some groups, like circumpolar Inuits who rely on fish and marine mammals that are contaminated. Furthermore, the nutritional benefits of the mother's consumption of dairy and fish to offspring could outweigh detrimental influences, if any, of PCB. For example, the n-3 fatty acids in fish may have a beneficial effect on neurodevelopment (29). If adverse effects of background-level exposure were certain, other measures to reduce exposure would also need to be considered. In this vein, increasing excretion *via* consumption of sucrose polyester has some experimental support, and food containing Olestra is readily available (30).

Despite the absence of certainty about the health effects of low-level exposure to POP, concern about this possibility led to the December 2000 signing by 122 countries of an international treaty banning 11 POP (aldrin, chlordane, dieldrin, endrin, heptachlor, mirex, toxaphene, PCB, hexachlorobenzene, dioxins, and furans) (31). Dichlorodiphenyldichloroethylene, one of the compounds studied by Karmaus *et al.*, is the most abundant metabolite of the insecticide DDT. According to the treaty, 25 countries are allowed to use DDT for malaria control. Beta-hexachlorocyclohexane (β-HCH) has already been banned in the majority of industrialized nations; use of an isomer, γ-HCH, or lindane, however, continues in many countries. The recent discovery of high PCB levels in Belgian foodstuffs (32) is yet another reminder that the time for complacency about the health effects of POP has not yet arrived.

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