Current Concentrations and Changes in Concentrations of PBDEs, Persistent Pesticides, and PCBs in Human Milk

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Introduction

Human milk is uniquely suited for infants, and breastfeeding remains the preferred choice for infant nutrition among many mothers. Breastfeeding is recommended by the World Health Organization, the U.S. Department of Health and Human Services, and the American Academy of Pediatrics. Though the advantages to both mother and infant associated with breastfeeding are numerous and have been well documented, questions have been raised regarding whether environmental chemicals in human milk adversely affect infant development and health. One traditional method for assessing health risks to infants from exposure to environmental chemicals through breastfeeding is to conduct a risk assessment, which incorporates an evaluation of infant exposures. Understanding the levels of the chemicals of interest over the course of lactation is critical to conducting a realistic exposure assessment. Whereas many past risk assessments assumed that concentrations of persistent lipophilic chemicals remain constant during lactation, several studies have documented changes in the concentrations of these chemicals in human milk during the course of lactation (reviewed by LaKind et al.[1]). Past studies showed that concentrations typically, but not always, declined during this time. The lack of sufficient data to quantify the changes in levels of these chemicals in human milk limits the ability to conduct realistic exposure assessments for breastfeeding infants. One of the objectives of our pilot study was to determine elimination rates for these chemicals during the course of lactation. Thus, we analyzed longitudinally collected milk samples (future results for this pilot study will include maternal serum samples, as well).

Material and Methods

A cohort of 30 study participants are being drawn from the population of women seeking prenatal care and women whose children receive pediatric care at the Pennsylvania State University College of Medicine. The study design is in accordance with the guidance from the *Technical Workshop on Human Milk Surveillance and Research on Environmental Chemicals in the United States*.[2] We analyzed the milk samples at the Centers for Disease Control and Prevention (CDC). The following chemicals were measured in serum (thought they had not yet been measured in serum) and human milk: polychlorinated biphenyls (PCBs), persistent pesticides, and polybrominated diphenyl ethers (PBDEs) (future analyses will include coplanar PCBs and dioxins/furans).

Participant selection and enrollment: The WHO guidelines[3] for selecting donors for the study of levels of PCBs and PCDDs/PCDFs in human milk are: (i) primiparae, (ii) healthy mother and child with a normal pregnancy; (iii) mother breastfeeding one child only; (iv) exclusion of mothers who have resided outside the area for more than 6 months during the last 5 years; (v) mothers who are exclusively breastfeeding. We required 3 years of residence in the area. In addition, we did not require exclusive breastfeeding for the duration of the investigation because of the limited number of women in the United States who exclusively breastfeed for extended periods of time (7.9% at 6 months).[4] All participants agreed to sign informed consent forms. Milk specimens were obtained by manual expression to avoid potential contamination of the sample by the breast pump. The participants were administered two questionnaires: The first questionnaire was administered at the time the first milk specimens were obtained, and included questions regarding personal, demographic, and lifestyle information for the mother and questions about the infant's health. The second questionnaire was administered at the time the last specimens were obtained, and included questions regarding the history of intake of infant formula or other foods, and health history. The timing of key participant events in the study is shown in Table 1.

Table 1. Schedule for human milk collection and administration of questionnaires.

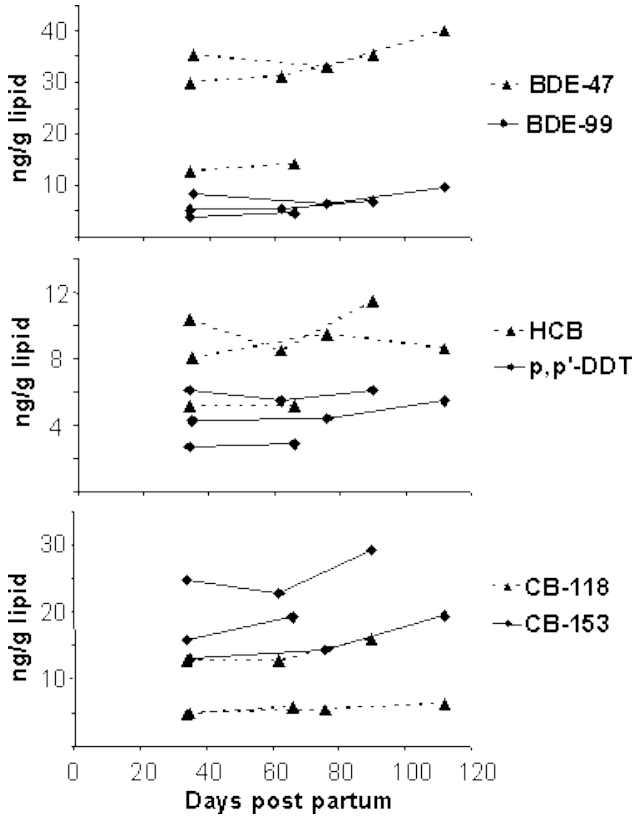
	Birth	1 month	2 month	3 month	End of lactation
Informed Consent	X				
Milk Sampling		X	X	X	X
Questionnaire		X			X

Analytical protocol: The human milk samples were stored and frozen and then shipped by next-day delivery to the CDC analytical laboratories for analysis. The method used to analyze the milk samples is based on solid-phase dispersion of the milk and elution of the lipid fraction using dichloromethane and gravimetric determination of co-extracted lipids. Final analytical determination after sample purification was made using gas chromatography coupled with high-resolution mass spectrometry. The methodology is described in Sjödin et al. 2004.[5]

Results and Discussion

Changes in concentrations over time: On the basis of previous studies reporting on elimination of persistent chemicals during lactation, we hypothesized that levels of persistent lipophilic compounds would decrease over the course of lactation. However, results for three participants for whom longitudinal data were available did not support this hypothesis. Figure 1 shows the changes in selected PBDEs (this being the first report of repeated sampling from the same woman for PBDEs in human milk), persistent pesticides, and PCBs, respectively, in milk lipids (ng/g) of three participants. The levels are relatively constant or slightly increasing over time for all chemicals. Though additional data from this study (with a greater number of participants and with both milk and serum analyses) may or may not confirm these results, on the basis of these preliminary data, the apparent depuration of persistent chemicals from lactation is not observed over the first 3 months of lactation in these persons. Initial hypotheses for this result include the following: (i) previous levels of environmental chemicals to which these participants may have been exposed were low compared with levels reported from previous studies, and participants' intake (through diet and other routes of exposure) as adolescents and adults and loss (though breastfeeding) are at steady state; (ii) peripartum mobilization of lipid stores in the mother during lactation is contributing a greater percentage of the total environmental chemical mass in the breast milk (compared with intake through diet, etc.), especially if current environmental exposure is lower than in previous decades; (iii) weight loss of the mothers postpartum results in concentration of the organohalogen compounds in the adipose tissues, thus maintaining a constant or slightly increasing level in the milk that is in equilibrium with levels in the adipose tissues; and/or (iv) lactation does not contribute significantly to the body's clearance of the chemicals for these specific persons.

Figure 1. Changes in concentrations of 2,2',4,4'-tetrabromodiphenyl ether (BDE-47), 2,2',4,4',5-pentaBDE (BDE-99), hexachlorobenzene (HCB), 2,2-bis(4-chlorophenyl)-1,1,1-trichloroethane (p,p'-DDT), 2,3'4,4',5-pentachlorobiphenyl (CB-118) and 2,2',4,4',5,5'-hexaCB (CB-153) in human milk during lactation over 120 days postpartum for three participants.



Comparison of Concentrations with Previously Reported Concentrations in the United States: The most recent data for persistent pesticides in the United States was from 1986 to 1993. Tables 2a and 2b show current and historical levels of these chemicals. For most of the pesticides for which U.S. data are available, concentrations in breast milk have declined over the past 20 years.

Table 2a. Concentrations of persistent pesticides (ng/g lipid) in human milk at approximately 1 month postpartum, collected during 2004-2005 from each of 6 participants (*=

HCB	β-HCCH	γ-HCCH	OXYCHLOR	t-NONA	pp-DDE	op-DDT	pp-DDT	Mirex
7.87	5.34	0.96	15.47	11.24	139.94	0.43	4.64	0.35
10.35	9.83	0.46	17.97	21.18	184.93	0.55	6.11	0.48
5.19	3.98	0.56	8.61	6.73	62.69	0.40	2.71	0.85
7.65	14.86	0.66*	23.84	27.35	188.05	0.80	6.07	5.56
5.87	4.44	0.52	11.45	12.34	124.97	0.36	5.37	1.53
8.05	6.80	0.10	7.71	9.15	98.56	0.62	4.27	0.36

Abbreviations: HCB, Hexachlorobenzene; β-HCCH, β-Hexachlorocyclohexane; γ-HCCH, γ-Hexachlorocyclohexane (Lindane); OXYCHLOR, Oxychlordane; t-Nona, Trans-Nonachlor; p,p'-DDE, 2,2-Bis(4-chlorophenyl)-1,1-dichloroethene; o,p'-DDT, 2-(4-chlorophenyl)-2-(2-chlorophenyl)- 1,1,1-trichloroethane; p,p'-DDT, 2,2-Bis(4-chlorophenyl-1,1,1-trichloroethane.

Table 2b. Concentrations of persistent pesticides (ng/g lipid) in human milk collected post-1985 from previous studies.

HCB	β-HCCH	γ-HCCH	OXYCHLOR	pp'-DDE	op'-DDT	pp'-DDT	Mirex	(Reference)/YEAR
						203 ±		(6)/1986*
30±20	120±120	NA	60±40	954±1647	NA	164	NA	
9.60±8.92	NA	NA	NA	217±233	NA	NA	4.80±11.3	(7)/1993**
22	20	2	6	540	NA	20	NA	(8)/1985-87***

***Mean for 942 women, Arkansas. Mean based on quantifiable samples. **Mean for 100 samples from 98 women, New York. ***One pooled sample from 7 women, New York**

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