PBDEs IN BREAST MILK: WHERE DO WE GO FROM HERE?

Judy S. LaKind[1] and Cheston M. Berlin[2]

[1]LaKind Associates, LLC, 106 Oakdale Ave., Catonsville, Maryland 21228 USA
[2]The Milton S. Hershey Medical Center, Dept. of Pediatrics, Pennsylvania State University College of Medicine, M.C. HO85, PO Box 850, Hershey, Pennsylvania 17033 USA

Introduction

Breast milk is a complex mixture of endogenous substances (over 200 constituents, including lipids, proteins and carbohydrates) and exogenous substances.[1,2] Exogenous substances in breast milk derive from both "voluntary" exposures (e.g., medications, personal care products, alcohol, nicotine, illicit substances) and "involuntary" exposures to environmental chemicals. The World Wildlife Fund noted that over 350 environmental chemicals have been detected in breast milk, including persistent organic chemicals, volatile chemicals, and metals.[3] Recently, there has been a focus on reports of chemicals in breast milk referred to as polybrominated diphenyl ethers (PBDEs).[4,5,6,7] Exposures to these chemicals are thought to originate from the use of PDBEs in the manufacture of consumer products (in addition to occupational exposures). PBDEs, also known as "polybrominated diphenyl oxides," refer to a diverse group of chemicals with differing bioaccumulation potential and toxicity. Therefore, it is important to distinguish among the different PBDE compounds when discussing exposures and body burdens. It is equally important to consider what these studies do and do not tell us, since the fear of environmental chemicals in breast milk may prevent women from initially breastfeeding or breastfeeding for longer periods of time, this despite the well recognized importance of breastfeeding in the healthy development and well-being of infants.[8] Therefore, a careful examination of the available information on PBDEs in breast milk, as well as a review the strengths and weaknesses of data on environmental chemicals in breast milk, is warranted. In addition, efforts to develop a protocol for future breast milk monitoring programs are described.

Extant data on PDBEs in Breast Milk

There are three commercial PBDE products[9]: decabromodiphenyl oxide, or DBDPO (>97% DBDPO, accounting for >75% of PBDE production[10]), octabromodiphenyl oxide, or OBDPO (containing mainly brominated diphenyl oxide congeners ranging from deca- to penta-), and pentabromodiphenyl oxide, or PeBDPO (containing mainly brominated diphenyl oxide congeners ranging from hexa- to tetra-).[9] The PBDEs that have been reported in breast milk include the tri- to hexa-DBEs.[4,5,6,7] Hepta- to decabromodiphenyl oxides have not been reported in breast milk. The data on these chemicals, much of which were derived from pooled samples, are sparse (Table 1) and from a geographically limited area. This raises many important questions. For example, are these levels representative of levels in other countries? How much interindividual variability can one anticipate? Much of these data were based on samples collected during the first three months post partum and would be influenced by an unknown amount of depuration. At what rate are these chemicals depurated during lactation? Are these data based on similar sampling methodologies (in other words, was breast milk sampled the same way in 1972 as it was in 1996 – are changes in concentrations affected by sampling method?) Additional study on PBDEs in breast milk is clearly warranted.

Strengths and Weaknesses of Studies on Environmental Chemicals in Breast Milk
Studies of environmental chemicals in human milk are the main source of information available with which to estimate health benefits and risks to an infant who is breastfed rather than formula fed.[11] Each of these studies has strengths and weaknesses and, taken individually, can provide snapshots of concentrations of environmental chemicals in the breast milk of a small population at one time and place. Additionally, these studies can impart information on trends. Taken together, it is difficult to make widely applicable statements about levels of environmental chemicals in breast milk because of certain limitations, including lack of consistent sampling methodologies and reporting of the results.[11] Key limitations include[11]:

Sampling and analysis methodology. Methods for collecting breast milk samples vary, impacting the utility of the data. For example, in some studies, samples are pooled; others report results from individual samples. When samples are pooled, information on ranges and variability of concentrations between people or between feedings is lost. Variability in time of collection (e.g., during one feeding; combined samples from a 24-hour time period) also affects study results.

Incomplete reporting. Many of the published studies provide minimal or no information pertinent to interpreting the results, including information on the methodology for collection of breast milk samples, or characteristics of the participant that might influence study results (e.g., smoking habit, age, parity, dietary information, occupational exposure).

Non-representative sampling. Many breast milk monitoring studies have focused on small populations (in some cases one or two women) from a limited geographical area (e.g., one city).

Duration of sampling. Studies differ in timing of collection of breast milk samples. Some studies have focused on early lactation, others later on. Since concentrations of environmental chemicals in breast milk decline during the course of lactation,[11] these differences in sampling time create uncertainty in drawing conclusions about infant exposures. Similarly, few studies provide information on whether the mother is supplementing the infant with formula or other sources of nutrition.

Number and types of chemicals. To a large extent, the focus of studies on environmental chemicals in breast milk has been on chlorinated organic chemicals such as dioxins, furans, PCBs, and chlorinated organic pesticides.[2] A broader approach to selection of chemicals in breast milk is needed.

Where Do We Go from Here?
Since most experts in the fields of pediatric health and lactation agree that, except in unusual situations, breast feeding is the preferred nutrition for the infant, a better understanding of the levels of environmental chemicals in breast milk, particularly in the United States (US) where information is relatively sparse, is essential for predicting infant body burdens of environmental chemicals (i.e., infant exposures), first and foremost during the early days and weeks of lactation. Evaluating the limitations with the available sampling and analysis studies on environmental chemicals in breast milk and proposing a protocol for future studies is a basic component of the effort to develop a scientifically-based and consistent message to interested communities (for example, doctors, nurses, lactation specialists, and new mothers) on the risks and benefits of breast feeding.[11]

A carefully planned and executed program of breast milk sampling and analysis would serve to provide the information needed to assess infant exposures during nursing.[11] An Expert Panel on Breast Milk Monitoring for Chemicals in Human Milk, which would develop a protocol to be used as the methodological underpinning for a breast milk monitoring program in the US, is proposed. A breast milk monitoring program should include the following objectives: (i) obtaining information on levels of selected environmental chemicals in breast milk in women residing in the US; (ii) obtaining information on women from diverse geographic regions of the US and from different socioeconomic and demographic backgrounds; (iii) extending previous studies by analyzing for an increased number of environmental chemicals in breast milk; (iv) obtaining longitudinal information (from the same mother(s)) during the course of lactation so that the decrease in concentration of the chemical over time can be assessed; and (v) promoting harmonization of sampling and analysis protocols to improve the comparability of the results.[12] Assemblage of a database on depuration will produce more realistic estimates of infant body burdens and related "acceptable" levels. Empirical data can also be used in risk/benefit analyses comparing breastfeeding and formula-feeding. It will also be important to include outcomes research in this type of program. Finally, this type of program is useful for identifying environmental chemicals of emerging concern and assessing the efficacy of restrictions on use/release of chemicals.[10]

Acknowledgements
Funding was provided by the Brominated Flame Retardants Industry Panel of the Chemical Manufacturers Association.

References
1. Lawrence R.A. and Lawrence R.M. (1999) Breastfeeding: A Guide for the Medical Profession. Fifth edition. Mosby, Inc.
2. Jensen A.A. and Slorach S.A. (1991) Chemical Contaminants in Human Milk. CRC Press. Boca Raton, Florida. 298 pp.
3. WWF-UK. (1999) Chemical Trespass: A Toxic Legacy. June 1999.
4. Darnerud P.O., Atuma S., Aune M., Cnattingius S., Wernroth M-L. and Wicklund-Glynn A. (1998) Polybrominated diphenyl ethers (PBDEs) in breast milk from primiparous women in Uppsala county, Sweden. Organohalogen Compounds 35, 411.
5. Noren K. and Meironyte D. (1998) Contaminants in Swedish human milk. Decreasing levels of organochlorine and increasing levels of organobromine compounds. Organohalogen Compounds 38, 1.
6. Noren K. and Meironyte D. (2000) Certain organochlorine and organobromine contaminants in Swedish human milk in perspective of past 20-30 years. Chemosphere 40, 1111.
7. Meironyte D., Noren K. and Bergman A. (1999) Analysis of polybrominated diphenyl ethers in Swedish human milk. A time-related trend study, 1972-1997. J Toxicol Environ Health Part A. 58, 329.
8. American Academy of Pediatrics Work Group on Breastfeeding. (1997) Breastfeeding and the use of human milk. Pediatrics 100, 1035.
9. Hardy M.L. (1999) Summary and Update on the Toxicology on BDBPO, OBDPO, PeBDPO and HBCD. Brominated Flame Retardants Workshop. 4 November. Washington, DC.
10. Hooper K. and MacDonald T.A. (2000) The PBDEs: An emerging environmental challenge and another reason for breast-milk monitoring programs. Environ Health Perpsect 108, 387.

11. LaKind J.S., Berlin C.M. and Naiman D.Q. Infant exposure to chemicals in breast milk in the United States: What we need to learn from a breast milk monitoring program. Submitted.
12. WHO (1989). World Health Organization Environmental Health 34. Levels of PCBs, PCDDs and PCDFs in Breast Milk. Yrjanheikki E. J., ed. Copenhagen, Denmark. 92p.
13. Kruger C. (Thesis, in German) (1988). Polybrominated biphenyls and polybrominated diphenyl ethers – detection and quantitation in selected foods. Univ. of MÌ nster. Cited in: IPCS (WHO). Environmental Health Criteria 162, Brominated Diphenyl Ethers. 1994. ISBN 92-4-157162-4.

Table 1. Reported levels of specific PBDEs in breast milk and study characteristics

Chemical concentration on breast milk (ng/g lipid) (range and median)	Year sample collected	Study characteristics	Ref.
2,2,4'-triBDE (BDE-17)			
nd*	1972-1997	Pooled, 102-340 women, aged 27-31 years, collection 1 to 90 days post partum#	7
2,4,4'-triBDE (BDE-28)			
nd – 0.19	1972-1997	#	7
2,2',4,4'-tetraBDE (BDE-47)			
0.06 - 2.28	1972-1997	#	7
0.331-16.1 (1.83)	?	Primiparous, n = 39, aged 22-36 years**	4
2,3',4,4'-tetraBDE (BDE-66)			
nd - 0.07	1972-1997	#	7
2,2',4,4',6-pentaBDE (BDE-100)			
nd - 0.42	1972-1997	#	7
0.060-5.14 (0.340)	?	**	4
2,2',4,4',5-pentaBDE (BDE-99)			
nd - 0.48	1972-1997	#	7
0.181-4.47 (0.442)	?	**	4
2,2',3,4,4'-pentaBDE (BDE-85)			
nd - 0.07	1972-1997	#	7
2,2',4,4',5,6'-hexaBDE (BDE-154)			
nd - 0.05	1972-1997	#	7
0.003-0.270 (0.06)	?	**	4
2,2',4,4',5,5'-hexaBDE (BDE-153)			
0.01 - 0.46	1972-1997	#	7
0.255-4.32 (0.478)	?	**	4
Bromkal 70-DE (PeBDPO)			
0.62-11.1	?	25 women, Germany	13
50	?	1 Chinese woman	13

*nd = not detected