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Mono-Ortho- and Non-Ortho-Substituted Polychlorinated Biphenyls in Human Milk from Mohawk and Control Women: Effects of Maternal Factors and Previous Lactation

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Abstract. Fifty-four individual human milk samples from 50 mothers (20 Mohawks and 30 controls) were analyzed for four non-ortho- and eight mono-ortho-substituted polychlorinated biphenyls (PCBs). Mean total coplanar PCBs concentrations were 49 ng/g and 55 ng/g lipid for Mohawk and control women, respectively. A statistical evaluation of all analytical data reveals no significant difference of total coplanar PCB level between Mohawk and control women. The level of these contaminants is influenced by the age of the mother, number of breastfed children, and length of nursing period. Older women, primiparae, and cigarette smokers had higher levels of coplanar PCBs. In general, women had higher levels of coplanar PCBs in the first lactation and in the earlier samples of a given lactation, while levels declined both with duration of breastfeeding and with number of children nursed.

The contribution of individual non-ortho- and mono-ortho-substituted PCB congeners to the total calculated toxic equivalent values (ΣTEQ) was assessed for the breast milk samples. The levels of polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in human milk of pooled specimens from Los Angeles, California and Binghamton, New York, widely separate cities in the United States (Schecter *et al.* 1989), were presented for reference purpose. The main contributions to the ΣTEQ were PCB congeners #118 (25.8 pg/g lipid), #126 (25 pg/g lipid), #105 (10.8 pg/g lipid), and #156 (7.4 pg/g lipid). Collectively, these compounds accounted for 70% of the ΣTEQ values. Based on the TEFs proposed by Safe (1990), the overall TEQs calculated for the monitored PCBs, were about five times those due to total PCDD/Fs.

Polychlorinated biphenyls (PCBs) have been found in the milk of women from the general population in numerous countries (Jensen 1987; Schecter 1991). Most of these surveys focused on ortho-substituted PCBs. Recently, coplanar PCBs that are approximate stereoisomers of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) have been found to resemble 2,3,7,8-TCDD in toxicity to animals, with a toxicity relative to that of 2,3,7,8-TCDD ranging from 0.001 for mono-ortho coplanars to 0.01, 0.1, and 0.05, respectively, for tetra, penta, and hexa non-ortho coplanar congeners (IUPAC No. 77, 126, and 169) (Safe 1990). These congeners are present in different biological specimens at very high levels when compared with levels of PCDD/Fs (Voogt *et al.* 1990). Therefore, determination of coplanar PCBs is useful in evaluating the toxic potential of breast milk for infants.

Polychlorinated biphenyls are present in relatively high concentrations in fish, wildlife, and environmental samples collected in the vicinity of General Motors, Reynolds Metals, and Alcoa facilities in Massena, NY, which is adjacent to the Akwasasne Mohawk reservation (Stone *et al.* 1991; Flint and Vena 1991). The Mohawk Nation is a Native American community of nearly 10,000 persons located along the St. Lawrence River in New York, Ontario, and Québec. The contamination of local fish and wildlife is a major concern of the Mohawk people, since their tradition and culture emphasize the interdependence of man and his environment and because many residents formerly depended on local fish, waterfowls, and mammals for food. Therefore, breast-fed Mohawk infants may be at high risk of exposure to PCBs and other chemicals that concentrate in milk fat. In order to evaluate the health risk of the breast-fed infants at Akwesasne, which borders the industrial site, a study has been conducted to investigate levels of coplanar PCBs in milk of 20 Mohawk women and 30 control women. All of these (50) women are a subset of a larger superfund project study consisting of 53 Mohawk women from Akwesasne and 109 control women from the Women and Infant Care (WIC) clinics of Warren and Schoharie Counties in New York State who gave birth from 1988 to 1990 (Fitzgerald *et al.* 1992).

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Toxic equivalents (TEQs) have been developed as a means of expressing the toxicity of a complex mixture of different PCDD/Fs and PCBs in terms of an equivalent quantity of 2,3,7,8-TCDD, which is considered the most potent member of this family of chemicals (Safe 1990). Each of the non-ortho- and mono-ortho-substituted PCB congeners has been assigned a toxic equivalent factor (TEF) based on its toxicity relative to 2,3,7,8-TCDD, which is assigned a TEF of 1. TEQ values are obtained by multiplying the concentration of each potent PCB by its assigned TEF. Although several TEF schemes have been proposed, the one proposed by Safe (1990) is applied here for PCBs. It should be noted, however, that Safe's proposal of TEFs for PCBs has not yet received as widespread acceptance as the International TEFs developed by North Atlantic Treaty Organization Committee on the Challenges of Modern Society (NATO/CCMS) (NATO 1988) for PCDD/Fs. Nonetheless, it is interesting to derive TEQs based on this scheme to compare the possible contribution for PCBs relative to that of PCDD/Fs.

The purpose of this study was to compare the non-ortho- and mono-ortho-substituted PCB levels in human milk from the Mohawk Reservation with those from the control area and to evaluate the parameters which influence the contamination of human milk. Individual coplanar PCB concentration obtained from the present study and PCDD/F concentrations of pooled specimens from the two US cities obtained by Schecter *et al.* (1989) are used to determine their relative contribution towards TEQs.

Experimental

Sample Collection and Storage

Human breast milk samples were collected from individual mothers from 1988 to 1990. All donors were provided with hexane- and acetone-washed glass containers (with a Teflon top), questionnaires, and instructions on how to collect and store samples. They were asked to collect approximately 50–100 ml of milk. The samples were then kept frozen at −10°F to −20°F before shipment. The samples were packed with dry ice and shipped to the Wadsworth Center via Federal Express. Control samples were brought to the Wadsworth Center directly after collection and frozen.

Extraction and Cleanup of Human Milk

A modification of the AOAC hexane-ethanol method (Knox and Kaur 1986) was used. The frozen milk samples were thawed and shaken to ensure homogeneity. Twenty-five grams of milk samples was weighed into a 150-ml centrifuge tube. Fifty ml of ethanol was added to the centrifuge tube and shaken well. Then 25 ml nanograde hexane (Mallinckrodt, Inc.) was added and shaken vigorously for 1 min and was allowed to separate for 15 min. The upper layer was transferred with a disposable pipet to a 125-ml Erlenmeyer flask containing anhydrous Na_2SO_4. The aqueous residue was extracted twice more with 25 ml hexane. The combined extracts were diluted to 100 ml. Out of a final 100-ml hexane extract, 20 ml was used for a gravimetric lipid determination. Forty ml of the remaining hexane extract (containing 10 g milk) was concentrated down to approximately 1–2 ml in a Kuderna-Danish (K-D) flask with a three-balled Snyder column on a steam bath. The extract was quantitatively transferred to a 1-cm diameter glass column containing 10 g of 4% deactivated Florisil® and 2 g sodium sulfate. The column was eluted with hexane and the first 60 ml of the eluate was collected. Sixty mL hexane was concentrated down to 1–2 ml with K-D apparatus and then further concentrated under a gentle stream of N_2 to ~100 μl and subsequently chromatographed on high performance liquid chromatography (HPLC), using a porous graphitic carbon column (PGC) to isolate planar PCBs from non-planar PCBs (Hong *et al.* 1992).

Liquid Chromatography

The HPLC system consisted of a model 6000A solvent delivery pump, a U6K injector, and a model 440 UV absorbance detector. A porous graphitic carbon (100 × 4.7 mm, 7 μm particle size, Hypercarb, Shandon Scientific, Ltd., U.K., supplied by Keystone Scientific, Inc., Bellefonte, PA) was used for the isolation of coplanar PCBs. The PGC column was fitted with a 7040 Rheodyne switching valve to enable back-flushing of the column. A SP 4100 computing integrator (Spectra-Physics, Santa Clara, CA) was used.

Nanograde hexane (Mallinckrodt, Inc.) was used as the eluting solvent. The porous graphitic carbon column was conditioned by eluting with about 60 ml of hexane and then the sample was eluted with hexane at 2 ml/min for 2 min, back-flushed with the same solvent for 6 min. The PCBs were detected by a UV detector at 254 nm. The nonplanar PCBs and pesticides were collected as the first fraction of 4 ml; mono-ortho- and non-ortho-substituted PCBs were collected as the second fraction of 12 mL by reverse elution (Hong *et al.* 1992). The first fraction was reduced to 0.5 ml and the second fraction was reduced to 0.1 ml. Both fractions were analyzed by GC/ECD.

Identification and Quantitation

The PCB fraction was chromatographed on Ultra 2 (25 m × 0.2 mm × 0.33 μm film thickness, Hewlett Packard) and SB-Octyl 50 (50 m × 0.2 mm × 0.25 μm film thickness, Lee Scientific, Salt Lake City, UT) capillary column using a Hewlett-Packard 5890 gas chromatograph equipped with a ^{63}Ni electron-capture detector (ECD). Injector and detector temperatures were 250°C. The oven temperature schedule for the Ultra 2 column was as follows: initial temperature 100°C for 2 min, then programmed at 10°C/min to 160°C, then 1°C/min to 190°C, 2°C/min to 270°C, kept at 270°C for 2 min. The oven temperature schedule for the SB-Octyl 50 column was as follows: initial temperature 110°C for 2 min, then programmed at 10°C for 6 min, then 2°C/min until 300°C, kept at 300°C for 10 min. The calibration mixture that was used to quantitate 2 to 4 ortho-substituted PCBs in the sample was a 1:1:1:1 mixture of 200 ng/ml each of Aroclors® 1221, 1016, 1254, and 1260 (Bush *et al.* 1989). A coplanar PCB standard that contained 10 ng/ml each of four non-ortho- and eight mono-ortho-substituted PCBs was used to quantitate mono-ortho and non-ortho coplanar PCBs. PCBs were quantitated by relating peak areas in the sample GC pattern with those of identical retention time and known concentrations in the standard. Non-ortho coplanar PCBs were also confirmed by GC-mass spectrometry.

Controls

Three breast milk samples were fortified with a mixture of 12 mono-ortho and non-ortho coplanar PCBs at level of 1 ng/g whole milk. Acetone was used as fortification solvent, and the fortified samples were left standing at room temperature for 2 h before extraction. Solvent blanks were run through the entire analytical procedure, concurrently with the fortified samples.

Results and Discussion

Quality Control

The quality control procedure and the performance of the method for the determination of non-ortho- and mono-ortho-substituted PCBs in human milk have been described previously (Hong *et al.* 1992). Recoveries of mono-ortho- and non-ortho-substituted PCBs from fortified breast milk ranged from 90% to 104%, depending on the isomer. The solvent blank indicated no background interference in the determination of coplanar PCBs.

Statistical Methods

Statistical analyses were performed by the SAS statisical package (SAS 1990). Multiple linear regression was used to assess the relationships between potential determinants such as age, duration of breast-feeding, number of children, height, weight, education, dietary intake of contaminated fish, coffee, and alcohol consumption, and the level of coplanar PCBs in milk fat. In order to achieve a normal distribution of the residuals the coplanar PCB concentration was log-transformed. Analysis of variance (AOV) procedures were used to test for categorical variables. This procedure first entailed using an F-test to determine whether there was a significant overall difference among the geometric means of the various study group. T-tests for independent samples were conducted to compare each pair of geometric means. A finding was considered statistically significant if its two-tailed probability level was less than 0.05. Probability levels between 0.05 and 0.10, however, were also reported, because of the small sample size.

No statistical difference of total coplanar PCB levels in Mohawk and control women was shown. For this reason, correlation coefficients are based on all the milk samples from both Mohawk and control women. In examining lactation effects, data were restricted to four women for whom data were available from both 1-month and 3-month lactation.

Characteristics of Participants

Table 1 compares the Mohawk and control mothers regarding physical characteristics, sociodemographic factors, reproductive histories, and lifestyle habits before, during, and after the index pregnancy. The ages of the lactating mothers are in the range of 17–43, with a mean age of 26. The Mohawk mothers were 4 years younger on average than the control mothers when the index child was born ($p < 0.05$). The Mohawks had fewer pregnancies than the controls ($p < 0.1$), but there was no significant difference in the number of live births. The mean lifetime duration of breast-feeding was 41 weeks among the Mohawks versus 45 weeks for the controls ($p > 0.1$). Most women (92%) had a high school education, 18 mothers had college education or the equivalent, 20 women smoked, and 3 Mohawk mothers reported eating duck. Two Mohawk women reported that they were occupationally exposed to the General Motors site. Eighteen women were primiparous (with first birth). All the women breast-fed their child to at least some extent. In general, the Mohawk mothers reported healthier lifestyles than did the control group. They were less likely to smoke cigarettes, drink alcohol, or use prescription drugs other than vitamins and iron, and drank fewer cups of regular coffee per week.

Table 1. Arithmetic means for selected background characteristics of study participants

Characteristic physical	Mohawk (N = 20)	Control (N = 30)	p-values
Height (in.)	64	65	0.38
Weight (lb)			
Before index pregnancy	146	148	0.76
During index pregnancy	179	181	0.73
After index pregnancy	154	158	0.56
Quetelet index[a]			
Before index pregnancy	25	25	0.95
During index pregnancy	30	30	0.90
After index pregnancy	26	26	1.0
Fat content in whole milk	2.8	2.7	0.74
Sociodemographic			
Maternal age at index birth (yr)	24	28	0.0093
Education (yr)	13	13	0.71
Reproductive			
Total pregnancies	2.3	3.1	0.080
Total live births	2.0	2.3	0.35
Duration of life-time breast-feeding (wk)	41	45	0.86
Lifestyle			
Cigarette smoking (numbers/day)			
Before index pregnancy	2.1	8.8	0.0031
During index pregnancy	0.05	3.7	0.0054
After index pregnancy	0.05	4.2	0.0026
Alcohol consumption (% yes)			
Before index pregnancy	60	63	0.82
During index pregnancy	20	33	0.31
After index pregnancy	30	37	0.63
Coffee consumption (cups/wk)			
Before index pregnancy	7.3	15	0.079
During index pregnancy	3.2	6.2	0.16
After index pregnancy	3.0	9.8	0.010

[a]Quetelet index = weight (kg)/height^2 (m)

Regional Difference

Coplanar PCB levels in breast milk from the Mohawk Reservation and the control area and t-values and p-values from Student's t test are given in Table 2. For the calculations of arithmetic means, zeroes were used for those which were undetectable (< MDL). The mean concentration of individual mono-ortho and non-ortho coplanar PCBs do not show significant difference between Mohawk and control women ($p > 0.1$). The arithmetic mean of total coplanar PCB (the sum of 12 non-ortho- and mono-ortho-substituted PCBs) in milk fat was 49 ng/g for the Mohawk women, compared to 55 ng/g for the control women ($p = 0.47$ after log-transformation). The contribution of each coplanar PCB to their respective total coplanars in Mohawk and control milk samples is quite similar. Concentrations for #169 were all below the limit of detection (0.1 ng/g milk fat), PCB #126 could be detected in many

Table 2. Arithmetic mean of coplanar PCBs in the breast milk of Mohawk and control women (ng/g fat basis)

Congeners[a] (IUPAC no.)	MDL[b]	Mohawk (n = 20) Mean[c]	Mohawk (n = 20) Range	Control (n = 30) Mean[d]	Control (n = 30) Range	t	p-value
81	0.09	0.09	ND[e] (8)–0.44	0.15	ND(11)–1.1	0.50	0.62
77	0.13	0.52	ND(3)–1.6	0.43	ND(3)–1.3	0.26	0.79
123	0.06	0.62	ND(5)–6.2	0.43	ND(6)–2.2	0.12	0.91
118	0.07	24	1.7–82	27	5.6–87	0.60	0.55
114	0.06	2.7	0.15–8	2.9	ND(1)–13	0.044	0.97
105	0.08	12	0.64–67	10	2.1–32	0.049	0.96
126	0.12	0.29	ND(14)–2.1	0.22	ND(24)–3.6	1.09	0.28
167	0.06	1.6	0.11–6.2	2.5	ND(1)–8.8	0.95	0.35
156	0.05	5.6	0.4–19	8.6	0.23–32	1.42	0.16
157	0.06	1.5	0.12–6.9	2.5	ND(1)–9.4	1.50	0.14
169	0.10	ND	ND	ND	ND	—	—
189	0.06	0.37	ND(3)–1.6	0.65	ND(5)–4.7	0.88	0.38
Total		49	3.4–178	55	8.4–179	0.72	0.47

[a] In order of GC elution
[b] MDL = method detection limit
[c,d] Arithmetic means, zeroes were used for those which were undetectable
[e] ND = not detectable (<MDL). Number in parentheses indicates the number of samples that were not detectable

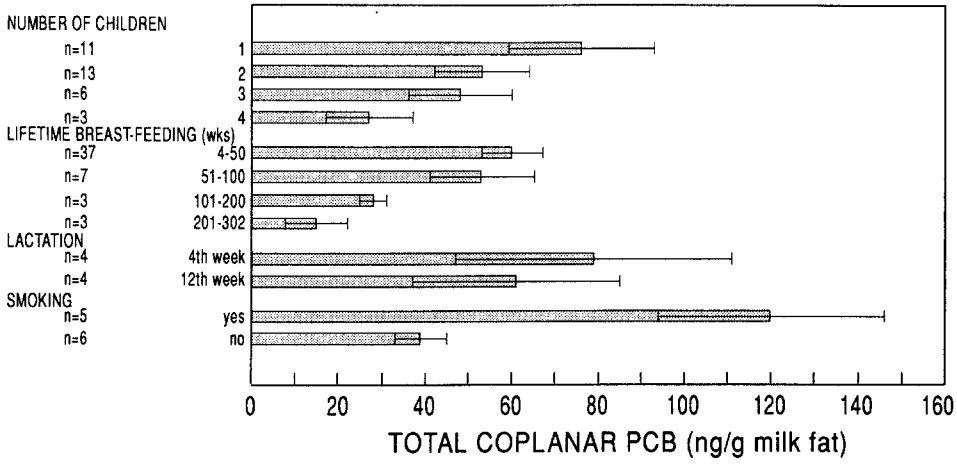

Fig. 1. Total coplanar PCB (arithmetic means) in milk fat versus number of children (p = 0.038 after log-transformation), lifetime duration of breast-feeding (p = 0.0014 after log-transformation), duration of lactation (p = 0.10 after log-transformation), and smoking (p = 0.012 after log-transformation)

samples (six Mohawk and six control samples) with values varying from 0.15 up to 3.6 ng/g lipid.

Parity

To evaluate the effect of parity (number of live births), the age factor must be controlled for. Because of the relatively small number of samples available in this study, we reduce the age variation by choosing the mothers with ages between 21 and 30 (N = 33). Statistical analysis (linear trend test) indicates a decreasing trend of coplanar PCB level with parity ($p < 0.05$). The effect of parity may be confounded by the duration of breast-feeding. Figure 1 shows that coplanar PCB levels in human milk decrease with the number of children (p = 0.038). Mean coplanar PCB levels in milk fat were found to be highest for women with the first child (76 ng/g lipid) and distinctly lower for women with the second, third, and fourth child (53, 48, 27 ng/g lipid respectively). This means decrease of 30–64% for total coplanar PCB concentrations in milk fat as compared with milk fat from mothers with their first child.

Duration of Lactation

Two samples each of milk from four mothers, three having their first child and one having her fourth child, were collected during the breast-feeding period (sample 1: 4th week, sample 2: 12th week). As shown in Figure 1, total coplanar PCB levels were 23% lower for the samples taken 12 weeks after delivery compared with levels of samples taking at the 4th week postpartum. While the results of lactation time controls were based on small numbers, the same women of only four mothers (one Mohawk mother and three control mothers), there was evidence of decrease in residue levels with lactation times, regardless of the geographical region sampled. This implies that excretion in milk may be a factor in lessening the mother's body burden; however, it also implies substantial exposure of the child.

Lifetime Duration of Breast-Feeding

The correlation between total coplanar PCB concentrations in milk fat and the lifetime duration of breast-feeding was investi-

gated. The statistical evaluation revealed a negative coefficient of correlation indicating a decrease of total coplanar PCB levels with increasing nursing time. Coplanar PCB concentrations in milk fat were significantly correlated with lifetime duration of breast-feeding ($n = 50$, $r = 0.48$, $p < 0.001$ after log-transformation). Figure 1 shows that mothers with 201–302 weeks lifetime duration of breast-feeding had the lowest coplanar PCB concentration (15 ng/g lipid), with 101–200 weeks breast feeding having an intermediate concentration (28 ng/g lipid), and with 4–50 weeks of breast feeding having the highest concentration (60 ng/g lipid). Due to the small number of such cases, these data cannot be generalized.

Maternal Age

For chemicals with a long half-life, such as PCBs, steady state is unlikely to be reached prior to the commencement of lactation, and higher milk-fat PCB levels are to be expected in older lactating women. However, increasing age may be confounded by higher parity, and this may explain the lack of a consistent relation between age and milk fat chemical levels in the published data (Di Domenico and Turrio 1990). Controlling for parity has been shown to increase the positive correlation between age and milk-fat levels (Drijver *et al.* 1988). To exclude the influence of the nursing period, only mothers nursing their first child were considered for this evaluation. In contrast to the decline with the length of the breast-feeding period, the coplanar PCB levels increase with the age of the women ($n = 18$, $r = 0.51$, $p < 0.05$ after log-transformation). This positive relation with age can be expected because of the long half-lives of PCBs.

Fish Consumption

From 1986 to 1989, there was a positive association between estimated lifetime exposure to PCBs from the consumption of local fish among the Mohawks and their milk PCB concentrations (Fitzgerald *et al.* 1992). These differences according to lifetime fish consumption, however, were no longer apparent among women who participated in 1990 (Fitzgerald *et al.* 1992). In the present study group, only three Mohawk women gave birth in 1989; the rest of the women gave birth in 1990. Statistical evaluation does not show association between fish consumption and milk coplanar PCB concentration in Mohawk women. This lack of an effect is probably due to the lower rate of fish consumption during pregnancy among Mohawk mothers who gave birth later (1990) relative to those who participated earlier (1986–1989).

Other Parameters

Factors other than age, breast-feeding period, and parity were also evaluated for potential relationships with the concentration of coplanar PCBs in human milk. These factors included weight, height, lipid content, smoking, drinking water, education, and dietary habits. Primiparous mothers with ages between 21 and 30 who are smokers ($n = 5$) contain on average significantly higher coplanar PCB levels (120 ng/g lipid) than non-smoking women ($n = 6$, 39 ng/g lipid) as shown in Figure 1 ($p < 0.05$). Although the number of cases analyzed is relatively low, there seems to be some indication that smoking results in somewhat higher coplanar PCB levels. Body mass index, education, lipid content, drinking water, and coffee and alcohol consumption do not have an association with the milk-fat level of coplanar PCBs.

Toxic Equivalent Quantity (TEQ)

The structure-activity relationship found for several halogenated aromatics has led to development of toxic equivalency factors (TEF) for individual congeners of PCDDs, PCDFs and PCBs. These factors express the toxicity of the compound relative to that of the most potent compound, 2,3,7,8-TCDD. The factors for PCDDs and PCDFs according to the Nordic model (Ahlborg *et al.* 1988), NATO (NATO 1988) and Safe (Safe 1990) are identical except for 1,2,3,7,8-PeCDF and the two HpCDFs. These differences are of minor significance in the assessment of human milk because these congeners are either absent or present in small amounts. Applying the NATO TEF values for PCDDs and PCDFs and the TEF values proposed by Safe for the PCBs, the concentrations of the compounds in milk were converted to toxic equivalents.

The human milk samples were not analyzed for PCDD/Fs; however, PCDD/F concentrations have been previously reported for pooled milk samples from urban areas of the USA (Tennessee, 14.6 pg/g lipid TEQ; Los Angeles, CA, 16.6 pg/g lipid TEQ and Binghamton, NY, 16.6 pg/g lipid TEQ) (Schecter *et al.* 1989, 1991). These give a good estimation of the PCDD/F body burden of the general population in USA. Table 3 summarizes the TEQ values obtained for PCDD/Fs in human milk of samples from groups of American women by Schecter *et al.* (1989) and the non-ortho- and mono-ortho-substituted PCB congeners found in the milk samples analyzed in the present study. Mean ΣTEQ values were 16.7 pg/g lipid for PCDD/Fs, 30 pg/g lipid for non-ortho-substituted, and 52.1 pg/g lipid for mono-ortho-substituted PCB congeners. When TEQs for non-ortho- and mono-ortho-substituted PCB congeners are calculated, levels of PCB congeners #118, 126, 105, 156, and 77 are the most important contributors towards the ΣTEQ values in human milk samples, followed by 2,3,4,7,8-PnCDF, 1,2,3,7,8-PnCDD, 2,3,7,8-TCDD, and 1,2,3,6,7,8-HxCDD. Table 4 shows the TEQ values of this study compared with those of Canadian, British, Swedish, and Japanese populations. The overall TEQ values for three mono-ortho-substituted PCB congeners #118, 105, and 156 accounted for 45% of the ΣTEQ values. These results were in good agreement with those reported by other authors for human milk samples in the British (Duarte-Davidson *et al.* 1992), Canadian (Dewailly *et al.* 1991) and Swedish (Norén and Lundén 1991) populations. These researchers, however, did not calculate TEQs for non-ortho-substituted PCB 81 and mono-ortho-substituted PCBs 123, 114, 167, 157, and 189. Data for non-ortho-substituted PCBs in breast milk of British population and mono-ortho-substituted PCBs in breast milk of Japanese populations are not available. Congener 126 is the most important non-ortho-substituted PCB in human milk. The TEQ values of non-ortho- and mono-ortho-substituted PCBs in this study were similar to those reported by laboratories in other industrialized countries as shown in Table 4. Although non-ortho- and mono-ortho-substi-

Table 3. Summary TEQ values for non-ortho-, mono-ortho-substituted PCBs, and PCDD/Fs in breast milk—Mohawks and controls combined

PCBs (IUPAC no.)	Mean concentration (ng/g fat)	Mean concentration (ng/ml wet[b])	TEF[a]	TEQ (pg/g fat)	TEQ (pg/ml wet)
Non-ortho					
81	0.13	0.004	0.001	0.13	0.004
77	0.47	0.013	0.01	4.7	0.13
126	0.25	0.007	0.1	25	0.7
169	ND	ND	0.05	—	—
Mono-ortho					
123	0.51	0.014	0.001	0.51	0.014
118	25.8	0.71	0.001	25.8	0.71
114	2.82	0.078	0.001	2.82	0.078
105	10.8	0.30	0.001	10.8	0.30
167	2.14	0.059	0.001	2.14	0.059
156	7.40	0.20	0.001	7.40	0.20
157	2.1	0.058	0.001	2.1	0.058
189	0.51	0.014	0.001	0.51	0.014
Σ(non-*o*+ mono-*o* PCBs)	52.9	1.46		81.9	2.27

PCDD/Fs	Mean concentration (pg/g lipid[c])	Mean concentration (pg/ml milk[d])	TEF[e]	TEQ (pg/g lipid)	TEQ (pg/ml milk)
2378-TCDD	3.3	0.091	1.0	3.3	0.091
12378-PnCDD	6.7	0.18	0.5	3.4	0.09
123678-HxCDD	30.5	0.84	0.1	3.1	0.084
23478-PnCDF	7.3	0.20	0.5	3.7	0.10
ΣPCDDs	327	9.0		11.6	0.32
ΣPCDFs	29	0.80		5.1	0.14
ΣPCDD/Fs	356	9.8		16.7	0.46

[a]TEF = toxic equivalency factors from Safe (1990)
[b,d]Data based on 2.75% fat content and density of 1.0 g/mL (density of cow milk is 1.028–1.035 g/ml)
[c]Data from Schecter *et al.* (1989)
[e]Toxic equivalency factors from NATO/CCMS (1988)
TEQ = toxic equivalent quantity

Table 4. Comparison of toxic equivalent quantity values (pg/g fat) of this study with other published data

	This study	Canada[a]	UK[b]	Sweden[c]	Japan[d]
Non-ortho					
81	0.13				
77	4.7	0.08		0.27	0.12
126	25	8.1		9.8	18.3
169	—	1.6		2.4	3.3
Σnon-ortho	30	9.8		12.5	21.7
Mono-ortho					
118	25.8	17.4	17.7	25.4	
105	10.8	4.4	10	6.5	
156	7.40	6.2	15.3	14.3	
123	0.51				
114	2.82				
167	2.14				
157	2.10				
189	0.51				
Σmono-ortho	52.1	28	43	46.2	
ΣPCDD/Fs	16.7[c]	13.3	32.8	20.7	12.9

[a]Data from Dewailly *et al.* (1991)
[b]Data from Duarte-Davidson *et al.* (1992)
[c]Data from Norén and Lundén (1991)
[d]Data from Matsueda *et al.* (1993)
[e]Data from Schecter *et al.* (1989)

tuted PCB congeners are less potent than PCDD/Fs, given the same health endpoint, they are present at much higher levels (ng/g compared with pg/g of PCDD/Fs) in breast milk, thereby making a much greater contribution towards the overall TEQ values. Thus, the overall TEQ for total non-ortho and mono-ortho coplanar PCBs based on the TEFs proposed by Safe (1990) (81.9 pg/g lipid) was about five times that obtained for PCDD/Fs (16.7 pg/g lipid) in the present study.

Conclusions

Within the limits of the study, no evidence was found that lactating mothers at Akwasasne had significantly higher total coplanar PCB levels in their breast milk than those of the control area. There are mainly two factors influencing the coplanar PCB levels in human milk: lifetime duration of breast-feeding and age of the mother. In general, older women and primiparae had higher levels, while levels decline both with time spent breast-feeding and with number of children. On a small sample in which there are no confounding variables, smoking appears to be associated with an increase in coplanar PCBs in breast milk. Other parameters are of minor importance. Using the recently proposed TEFs (Safe 1990), we conclude that, in our study populations, PCB represent a higher risk than PCDD/Fs. PCBs IUPAC # 118, 126, 105, 156, and 77 accounted for 90% of the TCDD-like toxicity of PCB. Therefore, it is important that these congeners be considered in assessing human body burdens of these classes of chemicals.

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