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Anthropometric, socioeconomic, and maternal health determinants of placental transfer of organochlorine compounds

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Abstract

The aim of this study was to relate placental transfer, quantified by the cord to maternal serum concentration ratio (C/M), of five organochlorine pesticides (OCP) hexachlorobenzene (HCB), β -hexachlorocyclohexane (β -HCH), γ -hexachlorocyclohexane (γ -HCH), p,p' -DDT, p,p' -DDE and 15 polychlorinated biphenyl (PCB) congeners (28, 52, 101, 105, 114, 118, 123⁺¹⁴⁹, 138⁺¹⁶³, 153, 156⁺¹⁷¹, 157, 167, 170, 180, and 189) to anthropometric, socioeconomic, and maternal health characteristics. We included into the study 1,134 births during the period 2002–2004 from two districts in eastern Slovakia with high organochlorine concentrations relative to other areas of the world. Only concentrations >LOD were taken into account. Variables as age, weight and height of mothers, parity, ethnicity, alcohol consumption, illness during pregnancy, smoking during pregnancy, hypertension, respiratory diseases, rheumatoid arthritis and diabetes mellitus, and birth weight were related to C/M. Results of regression analyses showed that C/M was predicted by several factors studied. Positive associations were observed for gestational alcohol consumption, fewer illnesses during pregnancy, maternal age, and maternal weight. Caucasians had a greater C/M compared to Romani for wet weight data of congeners 170 and 180 and in contrast C/M for HCB was greater in Romani. Our results show that drinking mothers compared to abstaining expose their fetuses not only to alcohol but to an increased level of several PCB congeners. A straightforward explanation of associations between C/M shifts and factors studied is very difficult, however, with regard to the high lipophilicity of OCPs and PCBs, changes in their kinetics probably reflect lipid kinetics.

Keywords

Placental transfer; Alcohol; PCB; Organochlorine pesticides

Introduction

Numerous studies show that exposure to environmental contaminants during fetal period or early childhood may cause long-term health effects such as increased susceptibility to cancer, damage to the immune and reproductive systems, and common chronic diseases in adult age. Low-level exposures before or shortly after birth often produce more damaging and longer-lasting harm than exposures at higher levels in later childhood or adult life (Shonkoff and Garner 2012; Brent 2004; Shonkoff et al. 2009; Guyer et al. 2009; Hertz-Picciotto et al. 2008; Grandjean et al. 2008). Persistent Organic Pollutants (POPs) are ubiquitous chemicals found in many components of the environment. POPs include organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs) which easily cross the placenta barrier, exposing humans during their early developmental stages. Assessment of prenatal exposure is very important in this connection and is mostly made indirectly by determining POP levels in umbilical cord blood (C). Information on placental transfer of POPs is obtained when C is related to concentration in maternal blood (M) at the time of delivery. Data on concentration of OCPs and PCBs and some of its metabolites in cord and maternal blood can be found in literature (Adetona et al. 2013; Porpora et al. 2013; Butler Walker et al. 2003; Bergonzi et al. 2011; 2009; Covaci et al. 2002; Tatsuta et al. 2012;

Tsukimori et al. 2013a; 2013b; Nakano et al. 2005; Suzuki et al. 2005; Jacobson et al. 1984; Sala et al. 2001; Abballe et al. 2008). In spite of this wealth of information, the knowledge on maternal anthropometric, socioeconomic, and health factors which influence the transfer of POPs through human placenta is limited. The aim of this work was to study the association between placental transfer of several OCPs and PCB congeners and these factors. As a marker of placental transfer was used the cord/maternal serum concentration ratio (C/M) of the respective chemical.

Materials and methods

Between 2002–2004, 1,134 mothers were enrolled in a birth cohort study in eastern Slovakia (Hertz-Picciotto et al. 2003; Park et al. 2007). We collected blood samples from mothers delivering in the Michalovce and Svidník district hospitals, eastern Slovakia. Michalovce district is home to a chemical manufacturing facility (Chemko, Strážske) that produced PCBs from 1959 to 1984. Of the 1,134 women enrolled in the study, maternal serum was available for organochlorine analysis on 1,103. All women provided written informed consent, and the study protocol was approved by institutional review boards at the University of California, Davis and the Slovak Medical University, Bratislava.

Whole maternal blood (20 ml) was collected from subjects just before delivery, allowed to clot, and centrifuged. Isolated serum was stored frozen at -18°C until analysis. To collect cord blood, the infant was held at the level of the introitus on the mother's abdomen to prevent a significant shift of the infant's blood volume. As soon as possible after suctioning, the cord was clamped and cut 4–5 cm from the infant's abdomen. After the infant was dried and stabilized and the umbilical base appeared normal, an umbilical clamp was secured to the cord 1–2 cm distal to the abdominal wall, and any excess length was cut. Cord blood collection (30–35 ml) was done by the obstetrician or assisting nurse. All tubes of maternal and cord blood specimens were refrigerated at $5\text{--}10^{\circ}\text{C}$ immediately after collection. Samples were transported to the biochemistry department of each local hospital within 2 h for the next procedure. Serum was isolated by centrifugation and stored frozen at -18°C till the analysis. During the mother's stay at the hospital, she was interviewed and asked to take a short IQ-like test (Raven's Progressive Matrices) (Raven and Raven 2002). Prior to discharge from the hospital, the mother was administered a questionnaire by a trained nurse and study coordinator. The maternal questionnaire collected information on the mothers' pregnancy, any complications, medications taken during pregnancy, previous pregnancy history, family medical history, lifestyle factors such as smoking and alcohol consumption, and sociodemographic, residential, house-hold (number of rooms and number of people living there), gardening, environmental exposure, and employment and occupational information. Further questions addressed their diet, including nutritional variety and adequacy of micronutrient intake, consumption of locally or home-produced animal products, or locally caught fish. Data to be abstracted from medical charts included: month prenatal care began, gestational diabetes, complications during pregnancy, medications given during pregnancy or during labor and delivery, and anesthesia during labor and delivery.

Solid-phase extraction followed by clean-up procedure and high-resolution gas chromatography with micro-electron capture detection was used for analyses of OCPs and PCBs in human serum samples (Conka et al. 2005; Kocan et al. 1994). Serum mixed with an equivalent amount of water: 1-propanol (85:15, v/v) mixture was applied on a conditioned SPE column (2-g C18, endcapped, Alltech, Deerfield, Illinois, USA). The analytes were eluted with an n-hexane/dichloromethane (1:1, v/v) mixture, and the eluate was concentrated. The extract was cleaned up on a multi-layer florisil–silica/H₂SO₄ column and eluted with hexane/dichloromethane (9:1, v/v). Isooctane was added as a keeper to the extract prior to concentration. Selected OCPs (hexachlorobenzene (HCB), β -hexachlorocyclohexane (β -HCH), γ -hexachlorocyclohexane (γ -HCH), *pp'*-DDT, *pp'*-DDE) and 15 PCB congeners (PCB-28, 52, 101, 105, 114, 118, 123⁺¹⁴⁹, 138⁺¹⁶³, 153, 156⁺¹⁷¹, 157, 167, 170, 180, 189, IUPAC nos.) were analyzed using a Gas Chromatograph 6890N (Agilent Technologies, USA) equipped with a micro-electron capture detector, and an Agilent ChemStation software, splitless mode, injection volume 2 μ l, a 60 m $\times$ 0.25 mm ID $\times$ 0.25 μ m FT DB-5 (J&W Scientific, USA) capillary column. The following temperature program was used: from initial temperature 110 °C (1.5 min) to 200 °C (0.2 min) at a rate of 30 and then 2.5 °C min⁻¹ to final temperature 305 °C (5 min). Five standard congener mixtures for 15 PCB congeners and 5 organochlorine pesticides established multilevel calibration curves. The method recovery was checked using PCB-174 as an internal standard. Only values limit of detection (LOD) were taken into account. Total serum lipids were estimated using enzymatic summation method (Akins et al. 1989). We report our results both on a lipid and non-lipid basis. C/M ratios were calculated for pairs in which data on concentration was available for both mother and her child.

Linear regression was used to determine the association between C/M and meaningful categorical or continuous predictors (parity, birth weight of the infant, mother age, height, weight, ethnicity, smoking and alcohol consumption during pregnancy, illnesses during pregnancy as diabetes mellitus, hypertension, arthritis, respiratory diseases). We considered the predictor as significant when *p* value was ≤ 0.05 . Calculations were carried out with statistics program SPSS 16, Softonic International S.L.

Results

The overall cohort of newborn babies is described in Table 1. Those of Romani ethnicity represented 20.3 % of the study population. Thirty-five percent of the women in the study smoked prior to this pregnancy, 41 % were primipara, their mean gestational age was 39.6 weeks, and the mean birth weight was 3,327.9 $\pm$ 499.1 g. The mean maternal age, weight, and height was 28.53 $\pm$ 4.86 years, 60.05 $\pm$ 11.68 kg, and 164.53 $\pm$ 6.25 cm, respectively.

The percentage of detection of OCPs and PCB congeners in maternal and cord blood serum samples is shown in Table 2. The concentration of OCPs was higher than the detection limit for most of samples except γ -HCH. From PCB congeners, only CB 118, 138⁺¹⁶³, 153, 156⁺¹⁷¹, 170, and 180 could be detected in ≥ 60 % of samples. The wet weight or lipid adjusted concentration of the 5 pesticides and 15 PCB congeners investigated are shown in Table 3. The concentrations may be higher than in reality as means and medians were calculated from samples $\geq$ LOD. However, the focus of this study is on ratios C/M which

were not biased by such proceeding. It can be seen that with lipid adjusted data most C/M values oscillate around 1, while with wet weight data, the values of C/M ratios were much smaller. This difference is due to high lipid solubility of this group of organochlorines and the much lower lipid concentration in fetal compared to maternal blood.

Table 4 summarizes results of multiple linear regression analysis which was used for identification of factors associated with C/M ratio. B is regression coefficient and the negative sign of regression coefficient means that the variables are negatively associated. We present only regression results in which $p < 0.05$. Unexpectedly, the strongest predictor of C/M was alcohol intake during pregnancy. Alcohol consumption explained a C/M increase for six PCB congeners, all with high percentage of detection, when data were expressed as wet weight and for two congeners when data were lipid adjusted. Thus, mothers not consuming alcohol during pregnancy had lower C/M values compared to mothers consuming alcohol, except PCB 189 with which the effect was opposite, however, on margin of significance. For pesticides alcohol was a predictor of increasing C/M value only with γ -HCH derived from wet weight data. The effect of smoking was observed with HCB. Smoking also predicted a decrease of lipid adjusted C/M for γ -HCH. Disease during pregnancy explained decreased C/M ratio for wet weight β -HCH and PCB 156⁺¹⁷¹. C/M for PCB 157, a congener with high detection percentage after both modes of expression, was greater in primiparas when compared to secundiparas and multiparas. On the contrary, for lipid adjusted β -HCH and γ -HCH, multiparity predicted higher levels compared to secundi and primiparity. Being a Romani means a lower C/M for PCB 170 and PCB 180 with wet weight data. On the other hand, Romani ethnicity does not protect before HCB. Birth weight predicted a decreased C/M for 138⁺¹⁶³, 170, 180, 189 and DDE. Mother weight and age were slight predictors of C/M. Mother weight predicted an increased C/M ratio for PCB 189 and age for congeners PCB 105 and PCB 170, however, of these congeners, only PCB 170 has a high percentage of detection. Total lipids significantly predicted a decreased C/M for PCB congeners 118, 138⁺¹⁶³, 156⁺¹⁷¹, 170, 180, and 189, all with high percentage of detection except PCB 189.

Discussion

Placental transfer of many environmentally and pharmacologically important compounds has been studied in vivo, by ex vivo human placental perfusion and more recently by quantitative structure–activity relationship methodology taking into account the molecular, physicochemical, and structural properties (Giaginis et al. 2011; Correia Carreira et al. 2011; Vähäkangas and Myllynen 2009; Giaginis et al. 2009; Myllynen et al. 2005; Myren et al. 2007). With regard to high lipid solubility, neutral character, limited protein binding, and rather small molecular size, the OCPs and PCBs pass the placenta barrier easily by means of passive diffusion.

The knowledge on anthropometric, maternal health or socioeconomic factors predicting toxicokinetics of OCPs and PCBs is abundant. The most important descriptors of behavior of these compounds in the body which have been studied are maternal age, education status, body height, pre-pregnancy weight, weight gain and BMI, gestational length, parity, diseases as diabetes, hypertension and preeclampsia, alcohol and smoking habits during

pregnancy, maternal occupation, place of residence, fuel type used for cooking, and marital status. From newborn variables interactions with sex, weight, length, head circumference, and Apgar score were described (Glynn et al. 2007; Llop, et al. 2010; Hansen et al. 2010; Adetona et al. 2013; Bergonzi et al. 2009; 2011; Freire et al. 2011; Arrebola et al. 2010; 2012a; 2012b; 2012c). To our knowledge, however, none of these determinants has so far been related to placental transfer of OCPs or PCBs. Nevertheless, some of these aforementioned factors may be even indirectly related to the process of placental transfer of organochlorines.

In our analysis, we have observed different signs of regression coefficient B for some OCPs and PCB congeners showing which variables are positively or negatively associated. This diversity in behavior can be explained by structural differences within OCPs and PCBs and by different physicochemical properties which determine their behavior within biological systems. Of factors potentially influencing C/M, parity is worth mentioning. A negative relationship was found between levels of some PCB congeners in cord blood and parity (Llop, et al. 2010), however, in this study, the cord blood concentrations were not paired with maternal blood concentrations which is needed for estimation of C/M, a marker of placental transfer. Another factor deserving comment is placental uptake of organochlorines which could also be indirectly related to placental transfer. Thus dioxins, structurally related to OCPs and PCBs, have been shown to accumulate in the placenta (Suzuki et al. 2005), however, the transfer of these compounds from maternal to cord blood was independent of placental accumulation (Tsukimori et al. 2013b). From anthropometric measures, higher maternal body mass index was significantly associated with higher endosulfan, a member of OCPs, concentrations in placenta, and greater maternal weight gain was significantly associated with higher *p,p'*-DDE concentrations (Lopez-Espinosa et al. 2007). Unfortunately, information on the simultaneous cord blood concentration is not available.

To explain the association between lower C/M and observed lower birth weight is very difficult. However, with regard to the high lipophilicity of PCBs, changes in their kinetics usually reflect lipid kinetics. Lower birth weight mostly reflects reduced placenta transfer of nutrients, including lipids. Although ethanol abuse and smoking during pregnancy are in focus of interest due to reduced growth of human fetus and other detrimental effects, the information on their effect on passage of toxic chemicals across the placenta is rather small. Thus evaluated was their effect on transport of vitamins or nutrients necessary for growth of the fetus (Jauniaux et al. 2007; Haggarty et al. 2002; Schenker et al. 1989) or DNA oxidation products (Rossner et al. 2009). In view of this, the association between alcohol consumption and C/M for several PCB congeners may be of toxicological interest, as this is very probably the first finding of ethanol effect on enhanced placental transfer of toxicologically interesting substances. So far, it was reported that alcohol consumption does not have any effect on placental transfer of some indicator substances (Veid et al. 2011; Phillips 1981). Noticeably, for almost the same group of PCB congeners of which C/M is associated with drinking, there was a positive association between total concentration of serum lipids and C/M. In other words, an increase of total serum lipid level predicted a decrease of C/M for the same congeners as those associated with alcohol consumption. With regard to high lipophilicity of PCBs, the C/M shifts in association with alcohol may be

secondary to the effect of alcohol on lipid metabolism. The effect of alcohol drinking on lipid metabolism is well known (Hata and Nakajima 2000; Hendriks et al. 1998; 2001; Brien et al. 2011). Nevertheless, disregarding the mode of action, the overall alcohol effect is important as the drinking compared to the abstaining mother exposes her fetus not only to alcohol but to an increased level of several PCB congeners.

The key finding of our study is that the anthropometric, socioeconomic, and maternal health factors are associated not only with functioning of main organs like intestines, liver, and kidneys, determining the kinetics of the OCPs and PCBs in the body, but also with functioning of a small but relatively extremely important part of the body system, the placenta. For most of the OCPs and PCB congeners placenta presents a very weak barrier as seen from the ratio of their maternal to cord blood serum concentration slightly over 1. Existence of factors worsening even that faint barrier function has been shown.

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Table 1

Characteristics of the study groups in the cohort from two districts of eastern Slovakia, 2002–2004

	Category	Number (n)	Percent (%)
Maternal age	18–<20	95	8.2
	20–30	850	73.1
	>30	189	16.3
	Missing	28	2.4
Maternal weight (kg)	38–50	205	17.6
	51–68	590	50.8
	69	189	16.3
	Missing	178	15.3
Maternal height (cm)	133–159	207	17.8
	160–169	587	50.5
	170	241	20.7
	Missing	127	10.9
Gestation length (weeks)	<37	30	2.3
	37–<42	1,036	89.2
	42	32	2.8
	Missing	64	5.5
Birth weight (g)	<2,500	49	4.2
	2,500–<3,500	630	54.2
	3,500	427	36.7
	Missing	56	4.8
District	Michalovce	811	69.8
	Svidník	323	27.8
	Missing	28	2.4
	Total	1,162	100
Ethnicity	Slovakian	869	74.8
	Romani	326	20.3
	Missing	57	4.9
Maternal education M	Basic schooling	237	20.4
	High school without graduation	290	24.9
	High school with graduation	512	44.1
	More than College/ University	89	7.7
	Missing	34	2.9
Maternal smoking	No	726	62.5
	Yes	408	35.1
	Missing	28	2.4
Maternal alcohol consumption	No	936	80.6
	Yes	198	17

	Category	Number (n)	Percent (%)
	Missing	28	2.4
Maternal diabetes history	No	1,121	96.5
	Yes	13	1.1
	Missing	28	2.4
Maternal respiratory history	No	917	78.9
	Yes	217	18.7
	Missing	28	2.4
Parity	0	471	40.5
	1	371	31.9
	2	196	16.9
	3	91	7.8
	4	2	0.2
	Missing	31	2.7
Sex of child	Male	573	49.3
	Female	534	46
	Missing	55	4.7
Exclusive breastfeeding duration (months)	0	44	3.8
	1–<6	868	74.7
	6	94	8.1
	Missing	156	13.4
Breastfeeding duration (months)	0	2	0.2
	1–6	640	55.1
	7–12	145	12.5
	>12	185	15.9
	Missing	190	16.4

Table 2

Percentage of samples with concentration of OCPs and PCB congeners LOD

	Mother	Cord	Mother	Cord	Mother	Cord	Mother	Cord	Mother	Cord
Pesticide	β -HCH		γ -HCH		HCB		p,p'-DDE		p,p'-DDT	
% of detection	85.9	82.9	27	24	96.3	96.3	99.7	99.3	96.3	97.7
PCB congener	28		52		101		105		114	
% of detection	38.8	12.8	14.5	12.5	19.3	19.7	18.8	7.2	13.3	4.4
PCB congener	118		123 ⁺¹⁴⁹		138 ⁺¹⁶³		153		156 ⁺¹⁷¹	
% of detection	83.6	69.4	14	12.3	100	99.4	100	99.8	95.5	67.5
PCB congener	157		167		170		180		189	
% of detection	18.9	7	51.9	18	99.8	98.7	100	99.9	30.8	12.3

Table 3

Concentration of organochlorine pesticides and PCB congeners studied in serum samples from umbilical cord blood and maternal blood

Concentration	Cord	Mother	Cord	Mother	Cord	Mother	Cord	Mother	Cord	Mother					
Pesticide															
Wet weight ng/ml serum	β-HCH	882	926	γ-HCH	256	281	HCB	1,027	1,038	p,p'-DDE	1,069	1,085	p,p'-DDT	1,052	1,031
Mean±SD	0.029±0.026	0.116±0.113	0.011±0.008	0.02±0.02	0.291±0.467	1.139±1.96	1.306±1.183	5.53±4.825	0.063±0.083	0.315±0.315					
n ratio	755	50	931	1,011	952										
Mean ratio±SD	0.286±0.294	0.727±0.938	0.342±0.645	0.255±0.198	0.242±0.829										
Median ratio	0.242	0.47	0.265	0.227	0.191										
Lipid adjusted ng/g lipid	882	926	281	1,027	1,038	1,069	1,052	1,031							
Mean±SD	11.3±10.4	11.3±10.5	4.45±4.67	2.03±1.87	117.3±183.7	108.7±163.8	521.1±448.3	533.3±426.9	24.6±25.4	30.6±29.3					
Median	8.61	9.193	3.307	1.431	73.989	68.097	393.348	426.769	17.427	21.41					
n ratio	755	50	931	1011	952										
Mean ratio±SD	1.189±1.903	0.578±0.749	1.373±2.408	1.021±1.021	0.898±1.205										
Median ratio	0.993	0.292	1.097	0.938	0.798										
PCB congener	28	52	101	105	114										
Wet weight ng/ml serum	136	409	161	212	213	219	47	146							
Mean±SD	0.033±0.038	0.087±0.154	0.022±0.025	0.075±0.234	0.110±1.155	0.068±0.108	0.018±0.023	0.056±0.114	0.014±0.011	0.030±0.065					
n ratio	88	20	59	54	16										
Mean ratio±SD	0.384±0.558	0.503±0.675	0.585±0.769	0.381±0.627	0.601±0.686										
Median ratio	0.228	0.269	0.37	0.187	0.289										
Lipid adjusted ng/g lipid W	134	404	157	211	210	216	47	144							
Mean±SD	12.59±10.72	7.96±10.50	7.78±5.21	5.35±4.68	12.73±15.91	6.13±6.63	5.98±4.36	4.49±5.45	5.89±5.44	2.36±3.49					
Median	9.001	4.588	6.451	3.964	8.601	4.244	4.56	3.051	3.608	1.487					
n ratio	88	20	59	24	16										
Mean ratio±SD	1.439±1.654	2.598±4.023	2.332±2.695	1.531±2.497	2.806±3.235										
Median ratio	1.062	1.215	1.315	0.674	1.157										
PCB congener	118	123 ¹⁴⁹	138 ¹⁶³	153	156 ¹⁷¹										
Wet weight ng/ml serum	749	920	154	1,074	1,099	1,078	1,099	729	1,051						

Concentration	Cord	Mother	Cord	Mother	Cord	Mother	Cord	Mother	Cord	Mother	Cord	Mother
	Mean±SD	0.037±0.066	0.167±0.301	0.021±0.058	0.036±0.043	0.284±0.364	1.237±1.218	0.389±0.454	1.881±1.703	0.025±0.034	0.179±0.292	
	Median	0.018	0.101	0.011	0.02	0.187	0.877	0.269	1.378	0.015	0.113	
	n ratio	639		57		1,016		1,020		662		
	Mean ratio±SD	0.195±0.201		0.511±0.560		0.224±0.171		0.200±0.097		0.150±0.155		
	Median ratio	0.163		0.336		0.2		0.185		0.118		
Lipid adjusted ng/g lipid	n	747	909	132	154	1,072	1,089	1,076	1,091	726	1,037	
	Mean±SD	13.68±18.67	15.60±18.53	6.63±8.67	3.38±3.77	110.5±120.6	124.6±155.6	152.1±151.4	191.8±224.7	9.47±10.74	16.14±17.06	
	Median	7.379	9.958	4.425	1.997	74.328	87.427	108.729	138.044	5.834	11.299	
	n ratio	639		57		1016		1021		662		
	Mean ratio±SD	0.768±0.733		2.273±2.862		0.894±0.716		0.808±0.568		0.577±0.510		
PCB congener	Median ratio	0.681		1.398		0.828		0.755		0.485		
	n	157		167		170		180		189		
	Wet weight ng/ml serum	76	208	194	571	1,066	1,099	1,079	1,098	339	339	
	Mean±SD	0.015±0.012	0.040±0.059	0.030±0.064	0.082±0.219	0.135±0.173	0.783±1.041	0.328±0.405	1.761±1.679	0.014±0.014	0.044±0.066	
	Median	0.011	0.024	0.015	0.043	0.087	0.527	0.213	1.241	0.009	0.03	
	n ratio	46		157		1,006		1,022		92		
	Mean ratio±SD	0.719±0.960		0.224±0.212		0.169±0.083		0.177±0.078		0.438±0.553		
	Median ratio	0.331		0.172		0.155		0.166		0.246		
	n	75	203	193	565	1,062	1,085	1,075	1,091	131	330	
	Mean±SD	5.81±4.54	3.47±3.79	10.78±16.15	7.04±11.06	51.40±53.37	72.63±68.17	125.9±127.4	180.4±207.8	5.132±4.115	3.777±3.628	
Lipid adjusted ng/g lipid	Median	4.005	2.442	6.144	4.12	35.446	52.192	86.19	124.11	3.604	2.679	
	n ratio	46		157		1006		1023		92		
	Mean ratio±SD	3.093±3.938		0.920±0.842		0.666±0.257		0.716±0.420		1.797±2.326		
	Median ratio	1.218		0.744		0.654		0.68		0.99		

Means and medians were calculated for serum concentrations and for the cord to maternal serum concentrations ratios. Wet weight and lipid adjusted data are presented

Table 4

Results of the multiple linear regression analysis

Parameter	Congener	Wet weight			Lipid adjusted		
		B	Std. Error	Sig.	B	Std. Error	Sig.
Alcohol consumption	γ-HCH	-1.117	0.508	0.035			
	PCB 118	-0.050	0.023	0.033			
	PCB 138 ⁺¹⁶³	-0.045	0.015	0.003			
	PCB 156 ⁺¹⁷¹	-0.045	0.017	0.010	-0.142	0.058	0.016
	PCB 180	-0.016	0.006	0.009			
	PCB 170	-0.018	0.007	0.009	-0.055	0.023	0.017
	PCB 189	0.390	0.189	0.043			
Smoking during pregnancy	PCB 153	-0.023	0.008	0.004			
	γ-HCH				0.853	0.320	0.012
	HCB	0.106	0.053	0.044	0.626	0.285	0.028
Disease during pregnancy	PCB 123 ⁺¹⁴⁹	-0.556	0.232	0.024	-2.798	1.261	0.035
	β-HCH	0.054	0.027	0.044			
	PCB 123 ⁺¹⁴⁹	1.138	0.215	0.000	6.047	1.168	0.000
	PCB 156 ⁺¹⁷¹				0.100	0.049	0.041
Diabetes	HCB	-0.625	0.128	0.000	-3.849	0.692	0.000
Primipara vs. multipara	β-HCH				-0.846	0.365	0.021
	γ-HCH				-1.954	0.707	0.009
Primipara vs. secundipara	PCB 157	1.958	0.908	0.042	8.243	3.639	0.033
	PCB 123 ⁺¹⁴⁹	-0.447	0.216	0.048			
	PCB 157	1.193	0.521	0.031	5.005	2.025	0.021
Secundipara vs. multipara	β-HCH				-0.852	0.351	0.015
	γ-HCH				-1.594	0.691	0.027
	PCB 123 ⁺¹⁴⁹	1.137	0.363	0.004	5.480	1.900	0.007
	PCB 114	-1.059	0.234	0.045			
	HCB	-0.105	0.052	0.044	-0.861	0.280	0.002
Romani	PCB 123 ⁺¹⁴⁹	0.517	0.249	0.047	3.099	1.313	0.025
	PCB 180	0.024	0.008	0.002			

Parameter	Congener	Wet weight			Lipid adjusted		
		B	Std. Error	Sig.	B	Std. Error	Sig
Birth weight	PCB 170	0.024	0.008	0.005			
	DDE	-0.000032	0.000016	0.040			
	PCB 123+149	0.00043	0.00019	0.034	0.002	0.001	0.032
	PCB 138 ¹⁶³	-0.00004	0.00001	0.002			
	PCB 180	-0.00003	0.00001	0.000			
Mother weight	PCB 170	-0.00003	0.00001	0.000	0.000	0.000	0.001
	PCB 189	-0.00003	0.00001	0.000			
	γ-HCH				-0.038	0.012	0.004
	PCB 189	0.014	0.006	0.036			
	PCB 105	0.040	0.013	0.005	0.190	0.056	0.002
Mother age	PCB 170				0.008	0.002	0.001
	HCb	-0.036	0.008	0.000			
	DDE	-0.021	0.003	0.000			
	PCB 118	-0.014	0.004	0.003			
	PCB 138+163	-0.018	0.003	0.000			
Total lipid content mg/mL	PCB 156+171	-0.014	0.003	0.000			
	PCB 180	-0.012	0.001	0.000			
	PCB 170	-0.012	0.001	0.000			
	PCB 189	-0.015	0.002	0.000			

The dependent variables were the umbilical cord to mother blood serum concentration ratio of 5 organochlorinated pesticides and 15 PCB congeners and the independent variables various anthropometric, socioeconomic, and health characteristics of mother (parity, mother age, height, weight, ethnicity, smoking during pregnancy, alcohol consumption during pregnancy, diabetes mellitus, hypertension, respiratory diseases, arthritis, illness during pregnancy, birth weight of the infant, total serum lipid concentration in maternal blood)