Biomonitoring of Environmental Chemicals in Pooled Pregnant Women and Cord Blood Serum Samples: Results from the Third Phase of the Alberta Biomonitoring Program

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Introduction

The Alberta Biomonitoring Program monitors exposures to environmental chemicals in the population of the province of Alberta, Canada. The first phase examined environmental exposures in pregnant women and the second phase investigated similar exposures in children[1,2]. Exposure to many environmental chemicals begins during gestation through transplacental transfer[3]. Transfer to the fetus during this sensitive stage may have health implications; thus, there is significant interest in fetal exposure to these compounds[4]. The third phase of the program included an updated suite of environmental chemicals in paired, pooled maternal and cord serum samples.

The use of pooling in biomonitoring studies has some advantages over individual sample analysis such as: more detectable levels above the limit of detection (LOD), which may lead to the calculation of population means that would not be possible with individual samples; cost savings for chemical analysis; and population data that may raise fewer ethical concerns than if the data is attributed to individuals[5]. All three phases have used pooled samples stratified by either age (Phase 2), or maternal age and geography (Phase 1 and 3).

The main objective of the research was to establish baseline levels of environmental chemicals in vulnerable populations within the province of Alberta using pooled samples. Trends can be examined across sample type, age, geography, and over time; and levels can be compared to other biomonitoring studies around the world. These baseline levels provide information that can inform public health interventions and policies.

Materials and methods

Participant recruitment and sample collection took place in the seven largest population centres in the province (Calgary, Edmonton, Red Deer, Lethbridge, Fort McMurray, Medicine Hat and Grande Prairie). Study recruiters

interviewed potential participants at hospital clinics and physician's offices to determine interest and eligibility. Eligible participants provided informed consent and filled out a questionnaire so samples could be placed in proper pools based on maternal age and geography. Maternal samples were collected from the first to third trimester, with the majority collected during the third trimester. Cord blood samples were collected at delivery.

The number of samples collected and pools prepared in each region and age category are provided in Table 1. Equal volumes of serum were added to each pool. Paired pools were created for maternal and cord blood serum. As shown in Table 1, the number of samples per pool differs by stratification. The mean and variance measures were adjusted for the number of samples per pool. To account for differences in population among the sites, population weights were applied when comparing means and variances across stratifications.

Table 1: Number of pools (number of samples per pool) per stratification

Site	Age Group (years)		
	18-25	**26-30**	**31+**
Calgary	3 pairs (12, 12, 20)	4 pairs (12, 12, 12, 21)	5 pairs (12, 12, 12, 12, 20)
Edmonton	3 pairs (12, 12, 12)	4 pairs (12, 12, 12, 20)	5 pairs (12, 12, 12, 12, 15)
Red Deer	1 pair (12)	2 pairs (12, 12)	2 pairs (12, 12)
Lethbridge	2 pairs (12, 20)	4 pairs (12, 12, 12, 12)	5 pairs (12, 12, 12, 12, 12)
Fort McMurray	5 pairs (12, 12, 12, 12, 12)	5 pairs (12, 12, 12, 12, 12)	5 pairs (12, 12, 12, 12, 12)
Medicine Hat	1 pairs (12)	1 pair (12)	1 pair (12)
Grande Prairie	2 pairs (12, 20)	2 pairs (12, 20)	2 pairs (12, 20)

Chemical analysis was performed at ALS Environmental (polychlorinated dibenzodioxins and furans, PCBs, organochlorine pesticides, PBDEs, PFASs, phenols, parabens, phthalate metabolites, methylmercury) and Alberta Centre for Toxicology (cotinine, phytoestrogens, metals and micronutrients). Statistical analysis was performed on chemicals that had detectable concentrations in at least 25% of the sample pools.

Results and discussion:

Chemicals from all classes analyzed have been detected in pooled maternal and cord blood serum samples. One benefit of using pooled samples is possibly higher detection rates of compounds, allowing for the calculation of mean levels of the compounds in the population[5]. This may be especially true for cord serum samples, which have lower concentrations of many of the persistent chemicals than maternal samples. Cord serum samples often have lower volume available than adult samples and a lower lipid content, both of which can lead to lower detection rates[6]. PBDEs are one of the chemical classes that concentrate in the lipid portion of the serum. Detection rates for PBDE congeners in various studies examining levels in paired maternal and cord individual serum samples are provided in Table 2. The detection rates in the Alberta study are higher or equal to those in the studies using individual samples.

Significant differences (based on the estimated 95% confidence intervals) in weighted mean concentrations of some chemicals were observed between maternal and cord pools. The percent distribution of four PCB congeners are displayed in Figures 1a and b. These congeners were chosen based on detection rate (100% for all) and their prevalence in other human biomonitoring studies. Similar distributions of PCB congeners have been noted in other studies using individual paired maternal and cord serum samples[4]. Mean maternal serum concentrations were significantly higher than cord serum concentrations for the following chemicals: PCBs (wet weight and lipid adjusted), dioxins and furans (wet weight), PBDEs (wet weight and lipid adjusted), DDE and heptachlor epoxide (wet weight and lipid adjusted), dieldrin, heptachlor, hexachlorobenzene, mirex,

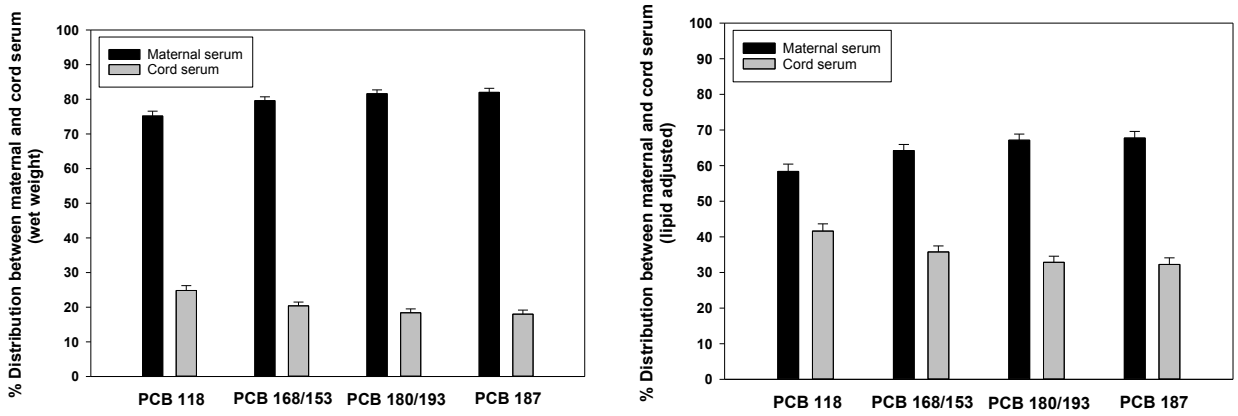
oxychlordane, trans-nonachlor (wet weight), daidzein, PFOS, PFHxS, PFNA, PFUA, B, Cu, Hg, Se and Sr. Cord serum concentrations were significantly higher than maternal concentrations for heptachlor (lipid adjusted), methylmercury (wet weight), methyl and propyl paraben, Cs, Fe, and Zn.

Table 2: Detection rates (%) of PBDE congeners in paired maternal and cord blood serum samples in the current study and studies using individual samples[a]

Study	BDE 47		BDE 99		BDE 100		BDE 153		BDE 154		BDE 209	
	Mat	Cord	Mat	Cord	Mat	Cord	Mat	Cord	Mat	Cord	Mat	Cord
MacDonald et al. (Alberta, n=62 [pools])	100	100	98	100	98	100	100	100	98	85	100	100
Antignac et al.[6] (France, n=91 (mat); n=90 (cord))	12	0	13	3	25	7	97	82	44	18	89	50
Fredericksen et al.[7] (Denmark, n=51 (mat); n=40 (cord))	80	45	37	28	27	5	98	100	45	20	94	0
Vizcaino et al.[4] (Spain, n=308)	22	36	60	32	-	-	94	43	85	14	31	15
Fisher et al.[8] (Canada, n=1927 (mat); n=1379 (cord))	66	5	19	1	22	1	44	3	-	-	-	-

[a] The six most detected PBDEs are displayed. The table is not exhaustive; studies were chosen based on LOQ values (similar to Alberta study) and congeners analyzed. "-" means the congener was not analyzed.

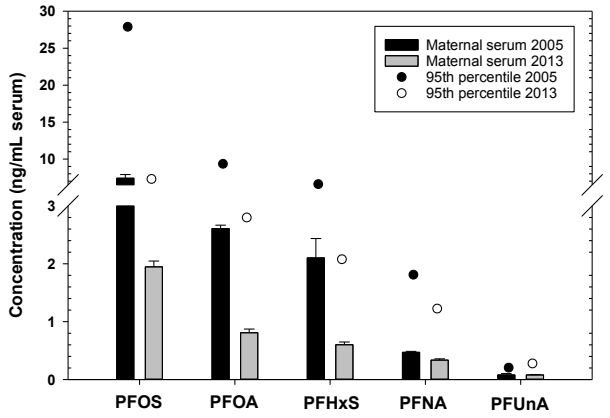
Figure 1: Percent distribution of PCB congener concentrations in maternal and cord serum (a) wet weight (b) lipid adjusted



Data from biomonitoring studies can also be used to track concentration trends over time. Maternal serum was analyzed in Phase 1 and again in Phase 3 of the Alberta Biomonitoring Program. Figure 2 shows the concentrations of five PFAS congeners detected in more than 25% of the pools from both the 2005 (Phase 1) study and the 2013 (Phase 3) study. The decreasing trend in PFOS, PFOA, PFHxS, and PFNA concentrations is similar to that observed in the U.S. over the same time frame[9]. The mean concentration of PFUnA has not changed significantly from 2005 – 2013 in the maternal serum from Alberta.

Baseline concentrations of environmental chemicals in maternal and cord serum were obtained for a subpopulation of Alberta using pooled samples. Trends across sample type, maternal age, geography, and time were investigated and found to be similar to other studies.

Figure 2: PFAS Maternal Serum Concentration Time Trend in Alberta



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