Fish consumption and breast milk concentrations of PCBs and chlorinated pesticides in the Astrakhan region, Russia

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Introduction

Polychlorinated biphenyls (PCBs) and chlorinated pesticides, such as DDT and its daughter products, bioaccumulate in the food chain and persist in human tissues for years. Prenatal and postnatal exposures to these compounds have been associated with adverse developmental, neurological and endocrine effects, immunotoxicity, reduced fertility and cancers in later life[1,2,3].

The pilot study presented in this paper assessed dietary habits and breast milk concentrations of these pollutants in the Astrakhan region, Russia. The city of Astrakhan (population 500,000) is located on the banks of the lower Volga River, 100 km from the Caspian Sea. The city has no major current or past industrial sources of PCB emissions. Local fish is an important food source for the residents of the Astrakhan city and especially for the villagers in the Volga delta.

Materials and Methods

The population of this pilot study consisted of nine primiparous breastfeeding women (four from the city of Astrakhan and five from villages in the Kamyziak district located in the delta of Volga) who gave birth to singleton normal-term infants in July-August 2000. Study participants, who were in maternity hospitals after the childbirth, donated breast milk samples and answered study questionnaires.

These questionnaires addressed respondent's age, education, occupation prior to maternity leave, past exposures to relevant organic chemicals, duration of residence in the Astrakhan region and town of current residence, smoking habits, height, weight before pregnancy and prior to birth, child's age (in days), sex and birth weight, breast feeding practice, number of people in the household, marital status, occupation of husband (if present) and respondent's nutrition. The nutrition questions addressed frequency of consumption of milk, sour cream, eggs, meat, meat products, poultry, and a variety of local fish species including perch, carp, pikeperch, pike, and catfish, during the past several years. Answers were categorized as less than one meal per month, one to four meals per month, two to seven meals per week and two or more meals per day.

Milk samples were analyzed for 54 PCB congeners (not including the non-ortho-substituted congeners) and common chlorinated pesticides: DDTs and their daughter products (*p,p'*-DDT, *o,p'*-DDT, *p,p'*-DDE, *o,p'*-DDE, and *p,p'*-DDD), hexachlorobenzene (HCB), mirex, aldrin, heptachlor, and two chlordane species, trans-nonachlor and oxychlordane. The samples were collected into 40 ml glass vials with Teflon-lined caps and transported to the Harvard School of Public Health for analysis. Extraction was conducted using the modified AOAC procedure[4]. Fat content was determined gravimetrically using aliquots of extracts. Extracts were concentrated to 1-

2 ml and cleaned using a chromatographic column packed with anhydrous sodium sulfate, deactivated silica gel and deactivated aluminum oxide. The analysis was conducted using the high resolution GC/ECD method. An internal standard (PCB IUPAC # 166) was used for quantification of the analytes. Five pairs of congeners, which coeluted on the capillary column, were reported as sums. Concentrations were corrected for the amount of the analyte measured in the procedural blanks. The results were expressed as concentrations of analytes in milk fat.

The Spearman rank correlation coefficients were used for assessing associations among ordinal questionnaire variables, and between breast milk concentrations of pollutants and these questionnaire variables. Generalized linear models for the normally distributed outcome were used for analysis of effects of questionnaire variables and breast milk concentrations of pollutants on birth weight. Due to a small sample size, these models were restricted to two explanatory variables.

Results and Discussion

All study participants had spent at least ten previous years in the Astrakhan region and seven of them had spent their entire lives in the town of current residence. Socioeconomic and demographic characteristics and anthropometrical parameters of study participants from the Kamyziak district and the city of Astrakhan were quite similar. Their ages varied from 17 to 27 years (a mean of 21 years). Three individuals had a high school education, three graduated from a technical college and the remaining three had an incomplete university education. One person was a laborer prior to her maternity leave, five were office employees or teachers, two were students and one did not have a specific occupation. Only one person smoked for a short time prior to her pregnancy and another person had been briefly exposed to paints and varnishes at the work place. Eight of nine study participants were married. Occupations of husbands were agricultural worker, laborer, driver, carpenter, gas industry worker, fisherman, policeman and security guard. The mean family size was 4.9 individuals suggesting that most study participants lived with relatives. All nine mothers were breastfeeding as frequently as the child wanted. Age of infants varied from one to 28 days with a median of four days (in Russia, women normally stay in a maternity hospital for a week; the presence of birth complications results in a much longer hospital stay). Five of nine infants were girls. Birth weight varied from 2,500 g to 4,135 g with a mean of 3,487 g (3,607 g in the Kamyziak district and 3,338 g in Astrakhan).

All study participants reported consumption of at least one fish species two to seven times per week. However, the frequency of fish consumption was generally higher in villages, while consumption of meat, meat products and sour cream was generally higher in the city of Astrakhan. Two village residents reported consumption of several fish species two or more times per day (more than one fish species might be consumed with every meal).

There was a strong negative correlation between consumption of meat and all fish species (for perch, $\rho = - 0.98$, $p = 0.0006$; for carp $\rho = - 0.87$, $p = 0.006$). Consumption of meat and meat products was positively correlated with higher education ($\rho = 0.64$, $p = 0.046$), while consumption of fish was negatively correlated with education (for perch: $\rho = -0.87$, $p = 0.026$; for carp, $\rho = - 0.73$, $p = 0.04$). Higher education was also correlated with a greater birth weight ($\rho = 0.69$, $p = 0.04$). The Spearman rank correlation between maternal meat consumption and birth weigh of infants was positive but not statistically significant, while correlations between maternal consumption of fish species and birth weight were negative but not statistically significant.

Breast milk concentrations of PCBs (the sum of all congeners analyzed, selected congeners and groups of congeners) and pesticides are presented in Table 1. Heptachlor was below detection limit in all samples while aldrin was detected only in one sample. The sample with the highest ΣPCBs concentration of 1028 ng/g fat was collected from a woman who reported no exposures to organic chemicals. Unlike all other samples, this sample had a large fraction of light congeners (Fig. 1-a) and higher concentration of mono-ortho PCBs than di-ortho PCBs (674 ng/g fat vs. 266 ng/g fat). The sample with the second highest concentration of ΣPCBs of 447 ng/g fat had the congener profile (Fig. 1-b) typical for dietary exposures and similar to all other samples.

Table 1. Concentrations of pollutants in breast milk, ng/g fat

Pollutant	Min	Median	Max
ΣPCBs	236	283	1028
Congener 28	0.92	3.9	305
Congeners 66/95	1.5	2.7	114
Congener 74	9.7	10.6	91.3
Congener 99	17.3	19.3	35.6
Congener 138	48.0	53.9	94.3
Congener 153	55.4	67.5	126
Congener 180	12.2	19.7	36.2
Mono-ortho PCBs	63.8	72.9	643
Di-ortho PCBs	133	171	305
ΣDDTs	613	1028	1278
p,p'-DDT	17.0	52.7	71.0
p,p'-DDE	558	943	1231
Chlordane	3.9	5.6	8.3
HCB	26.4	42.2	54.9
Mirex	0.32	0.62	1.2

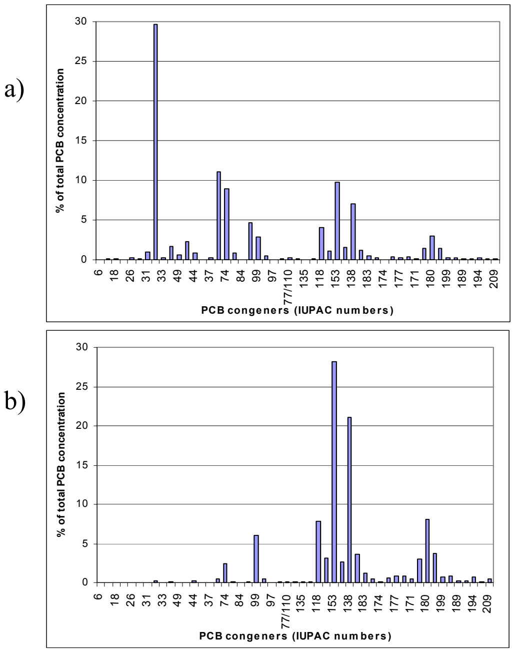

Fig. 1. Percent contribution of congeners to ΣPCBs concentration in milk:
a) ΣPCBs 1028 ng/g fat; b) ΣPCBs 447 ng/g fat.

There are statistically significant correlations between consumption of three fish species (perch, carp, and pikeperch) and breast milk concentrations of ΣPCBs, mono-ortho and di-ortho PCBs. Consumption of carp appears to be the strongest predictor of PCB concentrations ($\rho = 0.87$, p = 0.005 for both ΣPCBs and di-ortho PCBs). Consumption of meat and meat products appeared to be negatively correlated with breast milk concentrations of the same pollutants.

In the regression analysis, education (dichotomized as incomplete university or below) and maternal age are predictive of a greater birth weight (p = 0.002 and p = 0.08). Although the concentration of di-ortho PCBs is negatively associated with birth weigh in a univariate model (p = 0.065), the effect of maternal education explains most of this association.

Assuming that milk lipid concentrations of PCBs are 1.34 times higher than serum lipid concentrations[5], the median burden of congener 153 in this study was substantially lower than in the Netherlands, Germany and Northern Canada, and an order of magnitude lower than in the heavily exposed population of the Faeroe Islands[5]. The median concentration of ΣPCB in this study was similar to breast milk concentrations in the Northern European Russia[6] and Kazakhstan[7], but 40 % to 50 % higher than in the neighboring Russian city of Volgograd[8] and

Massachusetts[9]. The concentration of congener 28 in one sample (Fig. 1-a) was an order of magnitude higher than the maximum reported concentration of this congener in the Northern European Russia[6] and three times higher than in Kazakhstan[7]. Relatively high ΣPCBs concentrations with high fraction of light congeners (suggesting occupational rather than dietary exposures) have also been detected in a small fraction of breast milk samples from Massachusetts[10]. The median ΣDDTs concentration was similar to the median concentrations in Northern Russian cities[6] but three times lower than in Southern China[11], while *p,p'*-DDE was five times higher than in Massachusetts[9]. A mean *p,p'*-DDE/*p,p'*-DDT ratio of 17.4 suggests that the current DDT burden in the Astrakhan women results from relatively old applications of DDT.

It should be noted that in the Astrakhan region local fish is easily available and generally cheaper than meat and meat products. As a result, women of lower socioeconomic status tend to rely on fish as the major food source. Higher prenatal and postnatal exposures to PCBs and pesticides in their children are likely to be followed by higher dietary exposures throughout childhood, potentially aggravating other adverse developmental and health effects associated with low parental socioeconomic status. A larger study would be needed to address an association between exposures to chlororganic pollutants and health in the Astrakhan children, while the results of this small project can only suggest potential directions for future research.

All participants of this survey also contributed breast milk samples to a WHO-sponsored survey of PCBs and dioxins, which involved analysis of pooled samples from the city of Astrakhan and villages (S. Yufit and G. Mikhailov, personal communication). The results of PCB measurements in these two surveys are in good agreement.

Acknowledgements

The field data collection was financed from a Trust's for Mutual Understanding grant to the Harvard School of Public Health. The authors are grateful to Jennifer Adibi and Sergey Semenov for their support, and Raisa Stolyar and Scott Forsberg for chemical analysis of milk samples.

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