

Influence of the levels of polychlorinated biphenyls in human milk on the health of Lithuanian breastfed infants

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Environmental pollutants undoubtedly have a negative impact on human health, especially on the risk groups such as newborns and infants. In particular, significant risk factors could be attributed to polychlorinated biphenyls (PCBs) which are persistent organic pollutants. In our previous investigations, we determined PCB concentrations in the whole human milk of Lithuanian women and found the mean level to be 0.017 ± 0.002 mg/kg (0.495 mg/kg human milk fat). The concentration of PCBs in the whole human milk varied from 0.001 mg/kg to 0.057 mg/kg. Toxic mono-ortho-coplanar PCB congeners 118, 156 and 105 (numbered according to Ballschmiter et al.) comprised 13.2% of total PCBs.

Though the mean levels of PCBs in human milk of Lithuanian women were detected, there was no information available about the possible danger of PCBs to infant health in accordance with the duration of breastfeeding as well as with the total amount of consumed PCBs.

To ensure the safety of breastfeeding and to evaluate the harmfulness of PCB-containing human milk to infants the duration of breastfeeding and the total intake of PCBs were investigated. In February–March 2005, we randomly selected and surveyed 1543 mothers who were raising 12–18-month-old infants. During the study, an anonymous questionnaire was filled in. To perform the necessary investigations, the approval of National Bioethical Committee was obtained (No. 3, 02 02 2005).

We found that only 25.7% of the study women breastfed. According to the obtained results, as well as to the general WHO recommendation for the necessary daily breastfeeding, the average content of PCBs in infant's body was calculated. The results were compared with the average levels of PCBs in the milk of Lithuanian women.

Our results indicated that PCB concentrations in breastfed infant body were significantly below the dangerous levels.

Key words: polychlorinated biphenyls (PCBs), human milk, breast-feeding, infant

INTRODUCTION

According to scientific data, environmental pollutants undoubtedly have a negative impact on human health, especially in the population risk groups such as newborns and infants. In particular, significant risk factors could be attributed to polychlorinated biphenyls (PCBs) which are persistent organic pollutants.

Persistent organic pollutants (POPs) such as organochlorines have been of great concern due to their occurrence in high concentrations even in remote ecosystems, despite bans on production and usage (Guruge, Tanabe, 2001). Persistent organic pollutants is the common name for a group of chemicals which have certain properties. PCBs are a class of anthropogenic contaminants of long-standing environmental concern, represented by 209 congeners and attributed to POPs. PCB production, started in the USA, Germany and France in the 1930s, ceased when their production in Russia ended in 1993 (Breivik et al., 2004). The total amount of worldwide produced PCBs is estimated at 1.5 million tons (Ivanov, Sandell, 1992). It is assumed that 31%

of this amount has already escaped into the environment, 65% is still being used in closed systems, and only 4% has been liquidated in incinerators (Bagdonas et al., 2005).

Despite the ban on PCB production and market, the major part of these substances is still in use. PCBs have been used in a multitude of applications: in closed, semi-closed, and open systems. Today, PCBs are mostly used in closed systems since they are resistant to wastage and attention is focused on to preventing their release into the environment. PCB-containing oils have been used in electric switches and circuit breakers, as hydraulic oils in heavy machinery as well as a heat transfer medium in heat-exchangers and exchangers in industrial unit operations. PCBs have also been used in consumer-sized electrical appliances, such as light ballasts, in washing machines, etc. (Guidelines..., 1999). PCBs have historically been used in a number of open and semiclosed applications, and it is very unlikely that significant amounts of PCBs are left in open applications after several decades since their use. It means that the main part of open and semi-closed systems containing PCBs have been disposed to landfills. It is known that leach

from landfills is an important source of groundwater pollution. Landfills are one of hot spots of PCBs spreading to environment. Therefore, assessment of PCB-containing equipment and oils in closed systems which is still in use is not enough for assessment of the situation related to PCBs.

It was documented that in 2004 in Lithuania about 900 tons of equipment containing 316 units of transformers and 3720 units of condensers were used. In special storage places, additionally about 140 tons of waste containing PCBs are located. There are no enterprises or possibilities to decontaminate and eliminate waste in an environmentally friendly manner in Lithuania at the moment. Therefore, the equipment containing PCBs could be utilized only in foreign countries. It is obvious that the risk of PCBs to get into the environment could be real, as could be also latter the risk of contamination of foods and food products. In the stage, PCBs could pollute human breast milk and cause a real risk to infants (Valstybės...).

According to the Lithuanian Food Contamination Monitoring data, the highest mean concentrations of PCBs in food and food products were the following: in fish 0.059 ± 0.011 mg/kg (the bias interval from 0.0047 mg/kg to 0.146 mg/kg), in chicken 0.054 ± 0.03 mg/kg, in beef 0.04 ± 0.01 mg/kg, in cow milk 0.004 ± 0.001 mg/kg, in eggs $0.006\text{--}0.083$ mg/kg. According to the isomeric analysis data, food and food products mostly contain the metabolically active PCB derivatives – 153, 138, 180, 170 (nomenclature is according to Ballschmitter and Zell). Also, especially toxic monoorthocoplanic 118, 105 ir 156 derivatives (approximately 3–7% from the total amount of PCB) were found. It is important that the above-mentioned food products are in daily use, also by breastfeeding mothers, and thus can accumulate in the human body.

Consumption of animal fat and fish harvested from contaminated sites are the main sources of human PCB contamination. Researchers have also found that shellfish accumulate PCBs as they filter feed plankton. Cows grazing on contaminated grasses and feed can transfer them into their fat, meat, and milk. PCBs both bioaccumulate and biomagnify.

PCBs absorb readily from the gastrointestinal tract and then can deposit in liver and fat tissue. They have an ability to cross the placenta and are excreted in breast milk. Needless to say, a developing fetus ingesting contaminated milk may experience problems. Studies have shown an effect of PCBs on sperm motility, fetal growth, and neurological development in offspring (lower IQ scores, slower reflexes, attention deficit disorder, reduced memory capacity). Cases of liver cancer and malignant melanoma were noted, but their relationship to PCBs is not clear (<http://environmentalchemistry.com>).

The Lithuanian Food Contamination Monitoring programme was designed according to the World Health Organization food contamination monitoring principles and has been launched in 1993. The national Food Consumption Monitoring started in 1997. The national Food Contamination Monitoring embraces basic foodstuffs and most popular contaminants including PCBs. The samples are taken in specially designated places by trained inspectors and analysed in accredited laboratories. PCBs were detected in 65% of foodstuff samples.

PCBs are widespread, resistant to chemical degradation, and are found in contaminated food products, human adipose

tissue, human milk and cord serum (Longnecker et al., 1997). Historically, mass PCB poisonings have occurred as a result of food contamination (Jensen, Slorach, 1991; Fisher, 1999; Longnecker et al., 1997; Johansen et al., 1994; Rogan et al., 1980). In Japan in 1968, poisonings occurred because of PCB-contaminated rice oil (Jensen, Slorach, 1991). A similar incident occurred in Taiwan in 1979 from PCB-contaminated cooking oil (Jensen, Slorach, 1991).

PCBs occur as an environmental contaminant around the world. Because of their pervasive nature, PCBs' contribution to the overall human body burden of chemicals is significant. Many researchers report that almost all samples of human blood, fat or breast milk show some detectable level of PCBs (Longnecker et al., 1997). The majority of breast milk samples tested throughout the world show at least trace levels of PCBs (Jensen, Slorach, 1991; Dekoning, Karmaus, 2000; Huisman, 1995).

In our previous investigations, we determined PCB concentrations in the milk of Lithuanian women and found the mean level to be 0.017 ± 0.002 mg/kg (0.495 mg/kg in human milk fat). PCB concentration in whole human milk varied from 0.001 to 0.057 mg/kg. The toxic mono-ortho-coplanar PCBs congeners 118, 156 and 105 (numbered according to Ballschmitter et al., 1993) comprised 13.2% of total PCBs (Stukas, Maskeliūnas, 1995). The PCB level in human milk of Vilnius women ranged between 0.006 and 0.032 mg/kg. Evaluating the physical development, in our previous investigations we found the highest linear correlation between PCB level in human milk and child's weight at 2 years of age ($r = 0.64$) and high at 3 years of age ($r = 0.71$). Our investigations support the idea that PCBs consumed by children with breast milk have a long-term effect on physical growth and neurobehavioral maturation (Valiulis et al., 1995; Jučaitė et al., 1996; Jučaitė et al., 1999).

Cord serum PCB concentration fluctuated between 0.77 and 55.34 ng/g (mean 13.46 ± 11.65 ng/g). Toxic mono-ortho-coplanar PCBs congeners (118, 156 and 105) comprised 6.05% of total PCBs. One third of our group of women had higher than mean levels of PCBs. Cord serum and human milk PCB levels correlated significantly. Human adipose tissue PCB concentration fluctuated between 1.144 ± 0.290 mg/kg in Vilnius and 1.852 ± 0.238 mg/kg in Klaipėda. Toxic mono-ortho-coplanar PCBs congeners (118, 156 and 105) fluctuated between 0.156 ± 0.062 and 0.467 ± 0.074 mg/kg (Jučaitė et al., 1998). PCBs have been investigated by High-Resolution Gas Chromatography with Electron Capture Detection (Stukas, 1995). According to the Lithuanian Food Contamination Monitoring, the PCB level in human milk is stable. The samples are taken in specially designated places by trained inspectors and analysed in accredited laboratories (Krauskas et al., 2001).

Though the mean levels of PCBs in the milk of Lithuanian women were detected, there was no information on the possible hazard of PCBs to infant health depending on the duration of breastfeeding and on the total amount of consumed PCBs.

Human milk is the best food for the newborn, because it is the only source of necessary nutrients for the first 6 months of life, and it agrees well with the digestive system, stimulates the growth, physical and psychic development of the body, and the immunity of the newborn (Binns, 2004).

There are sufficient scientific data on the influence of long-term breastfeeding on newborn health (Horwood et al., 2001).

Nevertheless, there are also some scientific data that pollutants, including PCBs, could contaminate human milk.

On 18 May 2001, the WHO resolution was approved to urge the member states to promote exclusive breastfeeding until six months as a worldwide recommendation for public health, and to ensure the safe supplementary feeding by continuation of natural breastfeeding until two years of age and later. According to WHO data, breastfeeding until six months could be reached by 70–75% of mothers (Binns, 2004).

To ensure the safe breastfeeding status in our country and to evaluate the hazard of PCBs in human milk to infant health, it is necessary to study the breastfeeding terms as well as to calculate the total intake of PCBs with human milk to the infant body.

The aim of our research was to evaluate the danger of human milk containing PCBs to newborns with regard to the terms of breastfeeding. For that purpose, breastfeeding duration and PCB concentrations in human milk were investigated. The possible hazard of PCBs to newborns is discussed.

MATERIALS AND METHODS

Our investigations were performed in February–March 2005 in town and regional children's polyclinics and consultation centres of Lithuanian districts where randomly selected mothers raising 12–18-month-old children were surveyed. During the study, an anonymous questionnaire was filled in.

To perform the necessary investigations, the approval of the National Bioethical Committee was obtained (No. 3, 02 02 2005).

The questionnaire covered 39 questions. Most of the questions were of closed type. The common part of the questionnaire comprised the queries concerning the address, the newborn's age, and the number of children in the household, mother's age, education, and social conditions. Most of the questions were formulated to elucidate the duration of breastfeeding.

1543 mothers raising 12–18-month-old children were surveyed. The respondents were selected from Lithuanian districts, cities and counties. The number of respondents was selected according to statistical data, taking into account the birth rate per 1000 inhabitants in districts. 2000 questionnaires were distributed. The response rate was 77.2%.

The distribution of respondents according to the districts was the following: Vilnius district 401 (26%) of respondents, Kaunas 301 (19.5%), Klaipėda 165 (10.7%), Šiauliai 161 (10.4%), Panevėžys 125 (8.1%), Alytus 87 (5.6%), Telšiai 82 (5.3%), Utena 80 (5.2%), Marijampolė 78 (5.1%), Tauragė 63 (4.1%). The respondents were grouped according to their residential address, age, number of children in the household, education and social status.

The data analysis was performed using statistical SPSS package (version 11.0). The data were analysed using absolute values and percentages. The confidence interval (CI) of 95% was chosen, Pearson's coefficient (r) was used for the correlation, and the χ^2 test was performed for the difference in groups. The continuous variables were defined by dispersion, standard deviation and mode. The difference was considered significant when the p value was less than 0.05.

RESULTS AND DISCUSSION

According to their residence, all respondents were grouped as living in cities, district centres, and rural areas. Most of the respondents were living in cities (72.8%) and significantly less (10.5%) in district centres ($p < 0.05$).

The questionnaire was answered by females of different age. Namely, most of the respondents were aged 21–30 (65.1%); the 21–25-year-old age group comprised 524 persons (34%) and the 26–30-year-old age group 478 persons (31.1%). The least number of respondents were aged over 40 years (only 18 persons, or 1.2%). Most of the respondents had secondary or special education (53.9%), of them 34.2% had college and 11.7% not completed college education.

769 females (49% of all respondents) were raising the first and 556 (36%) the second child. The least number of respondents reported four or more children (60, or 4%). The respondents' social status was the following: 506 persons (33.6%) were on an official position, 523 (34.7%) were housewives, 347 (23%) were labourers, 132 (8.8%) were school and university students.

1456 respondents (95%) indicated exclusive breastfeeding (the infant was fed only breast milk) without any supplementary foods and drinks. According to our results, the 1 month duration of breastfeeding was typical of 70.6% of mothers, 4 months – 41.3%, 6 months – 25.7% of respondents, and 8 months and over – 8.2% of respondents (Fig. 1).

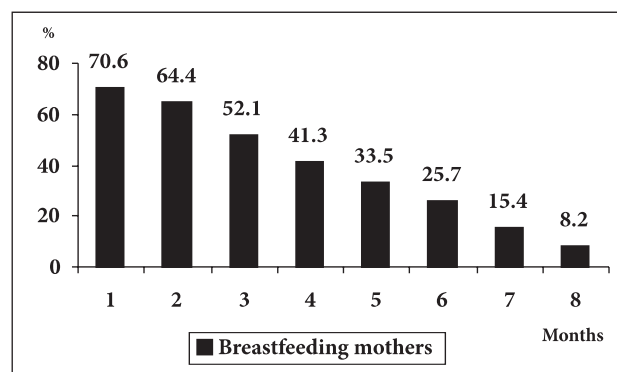


Fig. 1. The prevalence of breastfeeding in Lithuania

According to our results, the tendency of breastfeeding in Lithuania is positive. The number of breastfeeding women grows every year, though there is some lag from other EU states, for example, from Austria (data of 2003) where 92% of mothers breastfeed for 1 month exclusively, and 70% and 46% of respondents breastfeed until 4 and 6 months, respectively (Comparative analysis..., 2003).

No correlation was detected between breastfeeding and the place of residence of the respondents ($p = 0.579$). No breastfeeding at all was found in 6% of rural inhabitants, in 4.3% of mothers from region centres, and in 4.1% – from urban population. Breastfeeding until 4 months was revealed in 38.4% of rural inhabitants, in 38.5% of mothers from region centres, and in 46% – urban mothers. Mothers from rural locations, region centres, and urban regions breastfeed until six months (26.8%, 25.4% and 29.5%, respectively, $p > 0.05$).

The distribution of breastfeeding in women according to age groups was analysed in four main age groups from 20 to 35.

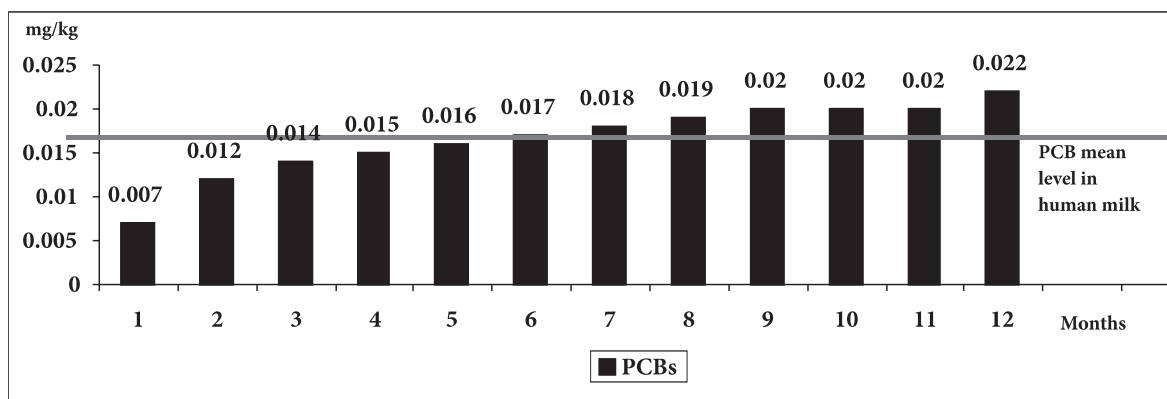


Fig. 2. Mean PCB amounts that could be consumed every month by infants versus the mean PCB level in milk of Lithuanian women

Mothers over 35 years due to the shortage of respondents were not taken into account. A negative correlation was found between the mother's age and breastfeeding duration ($r = 0.1$, $p < 0.05$). 55.9% of mothers aged under 20 breastfeed their newborns until two months, and even 74.8% of mothers aged 26–30 ($\chi^2 = 16$, $p < 0.05$). The breastfeeding period of 3–6 months was more typical of women aged 31–35, compared to the respondents aged under 20 or 21–25 years ($\chi^2 = 17$, $p < 0.05$).

No statistically significant difference was found between the duration of breastfeeding and the number of children in the household ($\chi^2 = 44$, $p = 0.298$). Breastfeeding duration of one month was common to 94.8% of mothers with one child in the household, whereas 96.0%, 94.6% and 88.3%, respectively, to mothers in households with 2, 3 and 4 or more children. The infants were breastfed until four months by 44.6%, 45.1%, 43.2% and 31.6% respectively by mothers having 1, 2, 3, 4 or more children. Infants until six months were more often breastfed by mothers having 3 children (34.4%), a little less having 2 children (30.0%), 27.5% – 1 child, and 16.6% – having 4 or more children.

Based on our findings on breastfeeding duration and taking into consideration exclusive breastfeeding of all infants daily per month, with regard to numerous human factors that do not influence breastfeeding duration, we calculated the mean daily intake of PCBs by infants per month and compared it with the mean PCB level in human milk in Lithuania (Fig. 2).

According to Fig. 2, during 6 months of breastfeeding the intake of PCBs with breast milk conforms to the mean PCB level in breast milk of Lithuanian women. The increase in cases of breastfeeding until one year is not significant. The former investigation of infant health indicated that such amounts of PCBs in infants could not be considered as health risk factors.

It could be stated that dangerous daily amounts of PCBs for infants are 0.07 mg/kg. Considering the average newborn weight growth, the intake of the mean amount of PCBs with breast milk was calculated. The results were compared with the hazardous concentration of PCBs (Fig. 3).

Figure 3 shows that the mean intake of PCBs in Lithuanian newborns (0.001–0.002 mg/kg) is significantly less than the dangerous dose – 0.07 mg/kg (Valiulis et al., 1995).

According to our results, exclusive breastfeeding in Lithuania is typical of 25.7% of women. So, following the WHO recommendations, it is necessary to further promote breastfeeding in

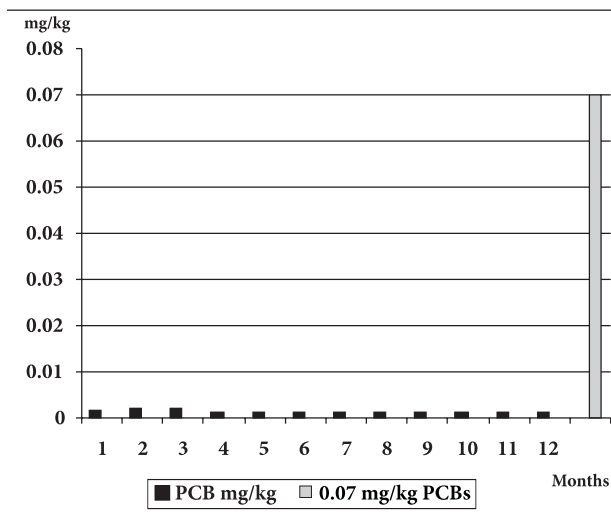


Fig. 3. The mean intake of PCBs with breast milk versus the hazardous concentration

our country, despite the low concentrations of PCBs detected in breast milk. It is important to reduce the risk of PCBs by means of administrative measures, for example, by calculating environmental pollution with PCBs and protecting the environment.

CONCLUSIONS

1. In Lithuania, exclusive breastfeeding is typical of 25.7% females.
2. During the 6th month of breastfeeding, the intake of PCBs with breast milk conforms to the mean level of PCBs in breast milk.
3. The mean intake of PCBs (0.001–0.002 mg/kg) in Lithuanian infants is significantly below the dangerous dose (0.07 mg/kg).

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POLICHLORINTŲ BIFENIŲ KONCENTRACIJOS MOTINOS PIENE ĮTAKA ŽINDOMIEMS KŪDIKIAMS LIETUVOJE

Santrauka

Aplinka bei joje esantys teršalai daro neabejotiną poveikį žmogaus sveikatai, ypač labiausiai pažeidžiamai gyventojų kategorijai – naujagimiams ir kūdikiams. Didelę riziką kelia ilgai aplinkoje išsilaikantys organinių teršalų grupei priklausantys polichlorinti bifenių (PCB).

Ankstesniais tyrimais esame nustatę PCB koncentraciją Lietuvos moterų piene – vidurkis $0,017 \pm 0,002$ mg/kg (0,495 mg/kg perskaičius į pieno riebalus). PCB koncentracija moterų piene kito nuo 0,001 iki 0,057 mg/kg. Toksiškų mono-orto-koplanarinių PCB izomerų 118, 156 ir 105 (numeracija pagal Ballschmiter) kiekis sudarė 13,2% nuo bendro PCB kiekio.

Nors PCB koncentracijos Lietuvos moterų piene nustatytos, tačiau iki šiol nebuvo įvertinta PCB keliama rizika naujagimių sveikatai priklausomai nuo žindymo trukmės ir žindant su motinos pienu į kūdikio

organizmą patekusių PCB suminio kiekio. Saugiam žindymui užtikrinti ir motinos piene esančių PCB galimai rizikai kūdikių sveikatai įvertinti Lietuvoje ištyrėme žindymo trukmę ir nustatėme žindant į kūdikio organizmą su motinos pienu patekusių PCB suminį kiekį.

2005 m. vasarį–kovą atsitiktinės atrankos būdu apklausėme 1543 motinas, auginančias 12–18 mėn. amžiaus vaikus. Apklausiant motinas, buvo pildoma anoniminė anketa. Tyrimui atlikti buvo gautas Lietuvos Bioetikos komiteto leidimas (2005 02 02, Nr. 3). Nustatėme, kad Lietuvoje kūdikius tik krūties pienu maitina 25,7% moterų. Remdamiesi gautais žindymo tyrimo rezultatais, orientuodamiesi į

maitinimą tik krūties pienu ir kūdikio mitybos poreikius kiekvieną mėnesį bei atsižvelgdami į mūsų gautus rezultatus, kad žindymui dauguma veiksnių neturi reikšmingos įtakos, apskaičiavome PCB, kiekvieną mėnesį per parą patenkantį į kūdikio organizmą, vidutinį kiekį ir palyginome su vidutine Lietuvos moterų pieno tarša PCB. Nustatėme, kad Lietuvoje žindomų kūdikių su motinos pienu gaunamų PCB paros dozė ženkliai mažesnė už kūdikio sveikatai riziką keliančią dozę.

Raktažodžiai: polichlorinti bifenilai (PCB), motinų pienas, žindymas, kūdikiai