Dioxin and dioxin-like compounds in breast milk from Norwegian mothers.

Hein Stigum[1], Merete Eggesbø[1], Anuschka Polder, Janneche Utne Skaare, Georg Becher, Tove Nicolaysen, Cathrine Thomsen, Per Magnus

[1]Norwegian Institute Of Public Health

Introduction

Human milk surveys for PCBs and chlorinated pesticides have been performed periodically since 1970[1] in Norway, in order to assess fetal and infant exposure to persistent organochlorine compounds (OCs). These studies have given valuable information concerning temporal trends in exposure level in Norway. Dioxin-like compounds in Norwegian breast milk have been investigated in three WHO coordinated rounds from 1987 to 2001[2]. However, due to pooling procedures these studies did not enable the assessment of the distribution of dioxins and dioxin-like compounds in human milk, nor the possibility of studying individual factors that may influence the levels. The purpose of this paper is to describe the distribution of dioxins and dioxin-like compounds in human milk from Norwegian mothers expressed as 2,3,7,8-TCDD Toxic Equivalents (TEQ), and to study the association between TEQ values and maternal age, education, parity and place of residence. Furthermore, we describe the contribution to the total TEQ values from the different compound groups dioxins (polychlorinated dibenzodioxins), furans (polychlorinated dibenzofurans), non-ortho polychlorinated biphenyls (PCBs), mono-ortho PCBs and HCB (hexachlorobenzene).

Materials and methods

Subjects

The study is based on a prospective birth cohort at the Norwegian Institute of Public Health (HUMIS). Mother and child pairs living in five selected counties in Norway are consecutively recruited after birth. The five counties represent northern, southwestern, and eastern parts of Norway, and include both coastal and inland areas. The milk samples are collected when the child is between 2 weeks and 2 months old, preferably by hand milking.

This paper includes data from 192 mothers where mono-ortho PCBs have been measured in the human milk, and a subset of 27 milk samples where dioxins, furans, non-ortho PCBs and HCB also have been determined.

Analysis

Analyses were performed by solvent extraction, clean-up and determination by GC-ECD (HCB), GC-LRMS (mono-ortho PCBs) or GC-HRMS (dioxins, furans and non-ortho PCBs) as described elsewhere [3, 4, 5, 6]. Concentrations expressed in TEQs on lipid weight basis were calculated for dioxins, furans and dioxin-like PCBs based on the toxic equivalent factors established by WHO in 1998. In addition, HCB was assigned a TEF of 0.0001 according to van Birgelen et al.[7].

Statistical methods

The data is a stratified sample (by county). Small counties are overrepresented, and weighted analyses in Stata were performed to correct for this [8]. Plots are based on unweighted data, since the Stata plot commands do not allow probability weighting.

The TEQ values have a skewed distribution with a few mothers showing high values. The TEQ values were therefore log transformed before the analysis, and the resulting means and confidence intervals were back-transformed in Table 1. The p-values are based on adjusted Wald tests.

We then used linear regression on the untransformed unweigthed data to estimate the adjusted association between TEQ level and the covariables: mothers' age, education, parity and region within the country.

Results and Discussion

TEQ values from mono-ortho PCBs

The distribution of (the unweighted) TEQ values of mono-ortho PCBs is shown in Figure 1. The values range from 0.9 to 12.3 pg TEQ/g lipids and the distribution is clearly skewed. The weighted, back-transformed mean is 3.1 pg TEQ/g lipids (Table 1.) The TEQ values increase with mothers age in the crude analysis, from mean 2.7 pg TEQ/g lipids in the group 27 years old and younger, to mean 3.9 pg TEQ/g lipids in the 32 years and older group (p=0.0002). There is a clear geographical variation in the mono-ortho TEQ values, with the South-West Norway having higher values than the East and the North.

In the adjusted analysis, the TEQ values increase with a value of 0.2 pg/g lipids per year increase in age. Adjusted for age, there is a clear decrease in TEQ values with increasing parity (-0.5 pg/g per child). There was no significant effect of education. However, there was a clear geographical variation in the TEQ values, with the South-West Norway having higher values than the East and the North. This is the first time that geographical variations in exposure to dioxin-like compounds in Norway have been demonstrated.

Total TEQ values (Dioxins, furans, non-ortho PCBs, mono-ortho PCBs and HCB)

The total TEQ values range from 5.0 to 19.5 pg TEQ/g lipids and the mean is 12.1 pg TEQ/g lipids. Excluding HCB, the TEQ values range from 4.6 to 18.1 pg TEQ/g lipids and the mean is 10.8 pg TEQ/g lipids.

Figure 2 shows the contribution to the total TEQ from the different component groups measured in the 27 human milk samples. Dioxin, furans, mono-ortho PCBs, non-ortho PCBs and HCB contribute 25, 20, 27, 17 and 10% of the TEQ respectively. If excluding HCB, the PCBs make up 49% (29.8%-68.2%) of the total TEQ. In a study on pooled milk samples from 2001, the relative amount of PCBs of the total TEQ was 60% [2]. Thus there is an indication that the contribution of PCBs to total TEQ has decreased, although this is not a statistically significant result.

Comparing the total TEQ level with earlier measurements is not straightforward, since the eligibility criteria were different. However, comparing the TEQ values in primiparous women indicates that there may have been a further reduction of dioxins and dioxin-like compounds in human milk in Norway from mean 16 pg TEQ/g lipid in 2001[2] 11.9 pg TEQ/g lipid in 2004 (95% ci: 9.4-14.3). The decrease is likely due to a decrease in the exposure to PCBs.

References

1. Johansen H.R., Becher G., Polder A. and Skaare J.U. (1994) J Toxicol Environ Health 42, 157.

2. Becher G., Haug L.S., Nicolaysen T., Polder A., Skaare J.U., (2002) *Organohalogen comp*. 56, 325..

3. Brevik E.M., (1978) *Bull Environ. Contam. Toxicol.* 19, 281.

4. Polder A., Odland J.O., Tkachev A., Føreid S., Savinova T.N., Skaare J.U., (2003) *Sci. Total Environ.*306, 179.

5. Polder A., Thomsen C., Becher G., Skaare J.U., Løken K., Eggesbø M., (2004) *Organohalogen comp*. 66.

6. Becher G., Skaare J.U., Polder A., Sletten B., Rossland O.J., Hansen H.K., Ptashekas J., (1995) *J. Toxicol. Environ. Health*, 46, 133.

7. van Birgelen AP. Environ Health Perspect 1998;106:683-8.

8. Stata Corporation (2001) Stata Statistical Software: Release 7.0. Stata Corporation, College Station. TX.

Table 1. Mean levels of mono-ortho PCBs in breast milk by covariates. Columns show number of subjects, (weighted, back-transformed), mean level in pg TEQ /g lipids with 95% confidence interval, and p-value for difference between groups.

	N	Mean	95% confidence interval	p-value
All	192	3.1	(2.9 , 3.3)	
Mothers age				
<=27 y.	63	2.7	(2.3 , 3.1)	
28-31 y.	74	3.0	(2.7 , 3.2)	0.0002
>=32 y.	55	3.9	(3.5 , 4.4)	
Education				
<12 years	5	2.5	(2 , 3)	
12-16 years	62	3.2	(2.7 , 3.7)	0.11
>16 years	116	3.1	(2.8 , 3.3)	
Part of country				
East	89	2.8	(2.5 , 3.1)	
South West	49	3.8	(3.4 , 4.3)	0.0001
North	54	2.7	(2.3 , 3)	
Parity				
1	62	3.0	(2.6 , 3.4)	
2	82	3.1	(2.9 , 3.4)	
3	40	3.2	(2.7 , 3.7)	0.3
4	8	3.8	(3.1 , 4.7)	

Table 2. Associations between human milk TEQ levels from mono-ortho PCBs and covariates. Columns show adjusted coefficients in pg TEQ/g lipids, with 95% confidence interval from linear regression.

	coefficient	95% confidence interval
Constant	-1.47	
Mothers age		
per year	0.2	(0.12 , 0.24)
Education		
<12 years	0.0	
12-16 years	0.2	(-1.18 , 1.52)
>16 years	-0.2	(-1.57 , 1.11)
Part of country		
East	0.0	
South West	1.4	(0.88 , 1.96)
North	0.0	(-0.48 , 0.55)
Parity		
per child	-0.5	(-0.78 , -0.16)

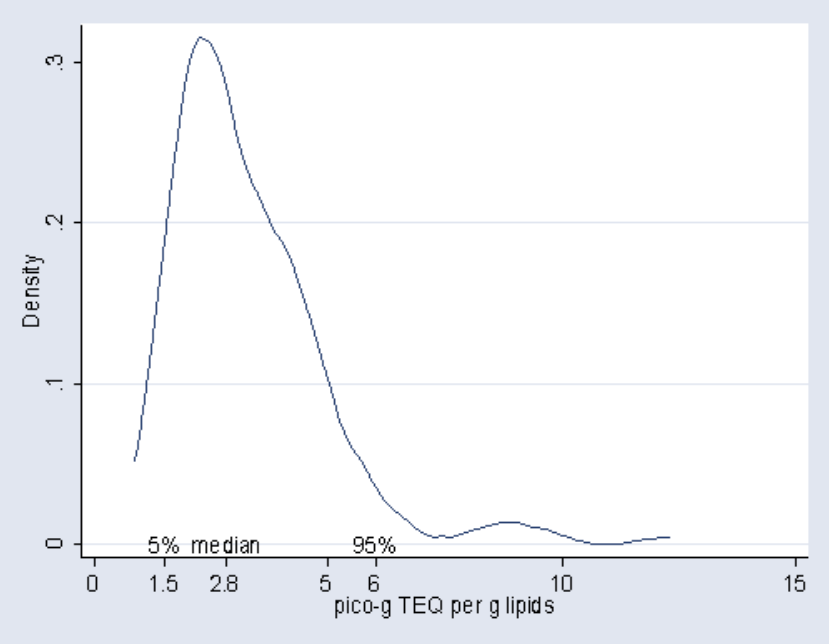

Figure 1. Distribution of TEQ values from mono-ortho PCBs in 192 samples of mother's milk

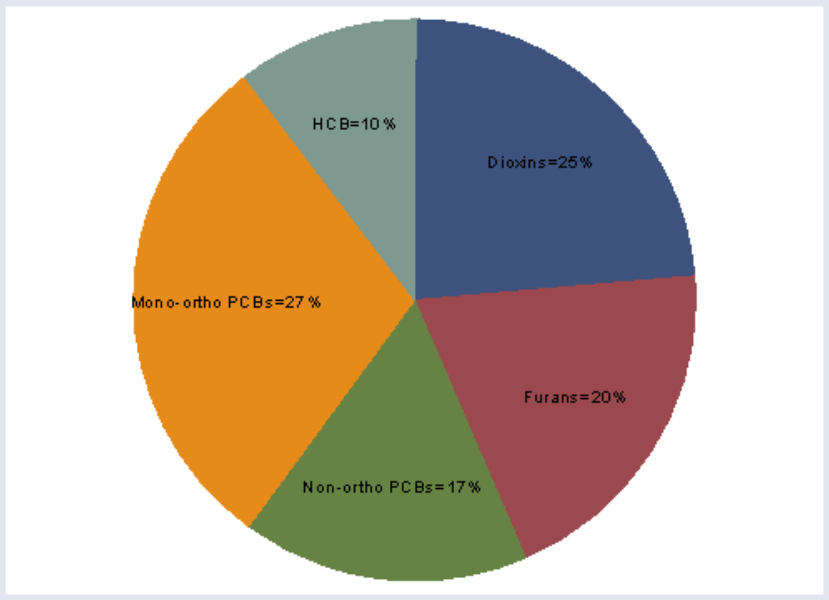

Figure 2. Contribution to total TEQ from five groups of OCs in 27 samples of mother's milk