THE PREDICTIVE VALUE OF DIETARY INTAKE ESTIMATIONS ON SERUM LEVELS OF SOME NON-DIOXIN LIKE PCBS

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Introduction

Food is the major source of exposure to polychlorinated biphenyls (PCB) in the Norwegian population. The Norwegian Institute of Public Health has, in collaboration with the Norwegian Food Safety Authority and The University of Oslo, conducted three dietary surveys that focus on consumption of fish and game. These foods may contain high levels of environmental contaminants, and are thus especially important with regard to dietary exposure. Based on these surveys, the aim of this study was to explore the predictive value of the dietary intake estimations on the serum levels of five of the non-dioxin like PCBs.

Materials and Methods

The Fish and Game Study was started in 1999 and is divided in sub-study A, B and C. All three studies were focusing on consumption of seafood such as crab, flatfish, halibut, crustaceans, perch and pike, and liver and kidney from game [1]. Study A (n=6015) was country representative and study B (n=5002) from selected inland and coastal municipalities using slightly different food frequency questionnaires. Based on intake estimates from study B, 700 people were invited to part C. Of these, 199 gave informed consent and answered a 12-page semi-quantitative food frequency questionnaire. In addition, serum samples were collected

PCB concentrations were determined in 130 of the serum samples. Preliminary results from these serum samples and the dietary intake estimations are presented here. Two-thirds of the participants were regular consumers of potentially highly contaminated foods and were especially selected to the study. The results will therefore show the upper end of the intake range which is possible through a Norwegian diet, and they will not be representative for the Norwegian population in general.

An extensive database was built comprising all available concentrations of PCB congeners in Norwegian foods. Food frequencies were converted into consumption (g/day) by multiplying with standard portion sizes. PCB intake was calculated by multiplying consumption with levels of PCB 101, 118, 138, 153, 180 in the respective foods (lower bound).

	PCB 101, 118, 138, 153, 180
Poultry and eggs	15
Liver/liverpaste bovine/sheep/pig	6
Meats	20
Dairy products/ice cream	15
Vegetable origin	8
Margarines and oils	4
Seagull eggs	4
Lean/semi lean fish	55
Fatty fish	132
Fish liver and roe	16
Marine oils	36
Crustaceans/shrimps	11
Total numer of analysis	**322**

Table 1. Number of analysis of foods included in the database for the five PCB congeners, divided into food groups.

The serum samples were extracted using solid phase extraction (Isolute 101, (200 mg) from International Sorbent Technology, Mid Glamorgan, UK) after small modifications of previously described methods [2,3]. Separation and quantitative determination of the PCBs were performed by capillary gas chromatography coupled to a mass spectrometer operated in the electron capture mode with methane as buffer gas. The PCBs were monitored on the *m/z* of their respective molecular ions, confirmed by controlling the isotope abundance ratio and the retention time, and quantified by internal standard calibration using C-13 labelled standards. The

uncertainty of the analysis was found to be about 20%. The lipid content of the serum samples was determined at The National Hospital of Norway (Oslo, Norway) according to a method described by Grimvall et al.[4]. Here we present only the same five PCB 101, 118, 138, 153, 180 in serum (lower bound) as in the dietary intake estimations.

Data analyses were performed with SPSS 13.0, Inc. Chicago, IL, USA. Linear regression using serum levels of each of the five PCB congeners as dependent variables were performed. Two models were established for blockwise entry; model 1 containing only the PCB intake estimate per kilo body weight (PCB-congener/bw) and model 2 containing this variable but in addition living inland versus coast, body mass index (BMI), smoking status, education at three levels, age and age^2. We compared the amount of explained variance (R square) for the two models for each of the five PCB-congeners.
The underlying linearity and constant variance assumptions were checked for each congener and each model, using a diagnostic residual plot. Cook's distance and delt-beta plots were used to identify outliers.

Results and Discussion
The two models were compared for each of the five congeners.

The full model (model 2) explained from 52% to 67% of the variance in the serum levels for all of the congeners except PCB101 (Table 1). This shows that the food frequency questionnaire can be used for predicting serum PCB concentrations given that we have information on location, body mass index, smoking status and age. Education had no statistically significant explanatory effect in model 2. The PCB intake alone (model 1) represented a quite low explanation but did contribute significantly for PCB 138, 153 and 180.

PCB	R2	
	model 1	model 2
101	0,3 %	9,9 %
118	2,7 %	52,1 %
138	14,4 %	66,9 %
153	17,6 %	65,1 %
180	18,0 %	64,8 %

Table 2. R^2 for the five PCB congeners.
Model 1 includes PCB/bw (ng/kg bw) and model 2 includes PCB/bw, inland/coast, body mass index, smoking status, education at three levels, age and age^2. The dependent variable is serum PCB (ng/g lipid) for each congener.

The results of the linear regression analysis show that the estimated intake of PCB 138, 153 and 180 had a significant and individual effect on the respective serum levels. This effect was not found for PCB 101 and 118. The covariates had variable impact on the serum levels as showed in table 3 to 7.

Table 3. Serum PCB101 for model 1 and 2 explained by B.

Model	Dependent Variable: serum CB101 ng/g lipid	B	95% Conf.Int	p	
1	Constant	9,72	8,57 , 10,86		
	pcb101 ng/bw	-0,23	-1,09 , 0,63	0,590	
2	Constant	-1,04	-11,47 , 9,38		
	pcb101 ng/bw	-0,42	-1,34 , 0,50	0,365	
	inland vs coast	-0,46	-1,92 , 0,99	0,528	
	body mass index	0,23	0,01 , 0,45	0,041	*
	high school vs "low educ"	1,17	-0,65 , 3,00	0,205	
	university vs "low educ"	1,19	-0,77 , 3,14	0,231	
	age	0,15	-0,18 , 0,48	0,359	
	age2	0,00	0,00 , 0,00	0,523	
	ever smoked vs never smoked	0,24	-1,27 , 1,75	0,757	

For PCB 101, the full model explained 9,9 % of the variance, but the only significant covariate in the full model was BMI. Increasing BMI with one unit the serum concentration of PCB 101 increases with 0,23 ng/g lipid. The estimated intake of PCB101 had no significant impact on the serum PCB101.

Table 4. Serum PCB118 for model 1 and 2 explained by B.

Model	Dependent Variable: serum CB118 ng/g lipid	B	95% Conf.Int	p	
1	Constant	16,65	11,78 , 21,52		
	pcb118 ng/bw	2,45	-0,30 , 5,19	0,080	
2	Constant	-3,59	-38,17 , 30,99		
	pcb118 ng/bw	1,02	-1,13 , 3,18	0,350	
	inland vs coast	-7,11	-12,06 , -2,17	0,005	*
	body mass index	1,24	0,52 , 1,96	0,001	**
	high school vs "low educ"	0,42	-5,64 , 6,48	0,891	
	university vs "low educ"	5,74	-0,71 , 12,19	0,080	
	age	-0,67	-1,77 , 0,43	0,229	
	age2	0,01	0,00 , 0,02	0,015	*
	ever smoked vs never smoked	-5,44	-10,46 , -0,41	0,034	*

For PCB 118, the full model explained 52,1 % of the variance and dietary intake estimations alone explained only 2,7 % (Table 2). Looking at the Bs we see that the "intake effect" is not statistical significant. The covariates BMI, inland versus coast, age2 and smoking status affects the serum PCB 118. High BMI, living by the coast, higher age and never-smokers have higher serum PCB118 concentrations.

Table 5 Serum PCB138 for model 1 and 2 explained by B.

Model	Dependent Variable: serum CB138 ng/g lipid	B	95% Conf.Int	p	
1	Constant	63,19	45,50 , 80,89		
	pcb138 ng/bw	11,74	6,37 , 17,12	0,000	**
2	Constant	74,09	-33,36 , 181,53		
	pcb138 ng/bw	7,97	4,22 , 11,72	0,000	**
	inland vs coast	-26,95	-42,39 , -11,52	0,001	**
	body mass index	1,58	-0,65 , 3,80	0,163	
	high school vs "low educ"	-4,99	-23,74 , 13,76	0,599	
	university vs "low educ"	5,82	-14,14 , 25,78	0,564	
	age	-3,09	-6,49 , 0,31	0,074	
	age2	0,06	0,02 , 0,09	0,001	**
	ever smoked vs never smoked	-10,72	-26,29 , 4,86	0,175	

For PCB 138, both the full and the reduced model showed great predictive value, 66,9% and 14,4 % respectively (Table 2). Increasing the intake of PCB138 with one ng/kg body weight increases the serum PCB138 with 7,97ng/g lipid. Living in the inland makes the serum value 26,95 ng/g lipid lower than for the coastal population. Increasing the age^2 with one unit increases serum concentration PCB138 with 0,06 ng/g lipid.

Table 6. Serum PCB153 for model 1 and 2 explained by B.

Model	Dependent Variable: serum CB153 ng/g lipid	B	95% Conf.Int	p	
1	Constant	81,34	60,09 , 102,59		
	pcb153 ng/bw	12,87	7,63 , 18,11	0,000	**
2	Constant	94,42	-49,47 , 238,31		
	pcb153 ng/bw	9,36	5,54 , 13,18	0,000	**
	inland vs coast	-33,15	-53,85 , -12,44	0,002	**
	body mass index	1,02	-1,97 , 4,01	0,499	
	high school vs "low educ"	-2,19	-27,35 , 22,98	0,864	
	university vs "low educ"	10,79	-15,99 , 37,57	0,426	
	age	-3,22	-7,79 , 1,34	0,164	
	age2	0,06	0,02 , 0,11	0,003	**
	ever smoked vs never smoked	-12,96	-33,84 , 7,92	0,221	

For PCB 153, both the full and the reduced model showed great predictive value, 65,1% and 17,6 % respectively (Table 2). Increasing the intake of PCB153 with one ng/kg body weight increases the serum PCB153 with 9,36 ng/g lipid. Living in the inland makes the serum value 33,15 ng/g lipid lower than for coastal population. Increasing the age^2 with one unit increases serum concentration PCB153 with 0,06 ng/g lipid.

Table 7. Serum PCB180 for model 1 and 2 explained by B.

Model	Dependent Variable: s_CB180 ng/g fett	B	95% Conf.Int	p	
1	Constant	69,00	50,74 , 87,27		
	pcb180 ng/bw	41,51	24,85 , 58,17	0,000	**
2	Constant	53,29	-73,03 , 179,61		
	pcb180 ng/bw	32,17	20,02 , 44,33	0,000	**
	inland vs coast	-23,52	-41,65 , -5,39	0,011	*
	body mass index	-1,43	-4,05 , 1,19	0,282	
	high school vs "low educ"	-2,25	-24,38 , 19,87	0,840	
	university vs "low educ"	0,46	-23,02 , 23,95	0,969	
	age	0,36	-3,64 , 4,36	0,858	
	age2	0,03	-0,01 , 0,06	0,156	
	ever smoked vs never smoked	-14,94	-33,22 , 3,34	0,108	

For PCB 180, both the full and the reduced model showed great predictive value, 64,8 % and 18,0 % respectively (Table 2). Increasing the intake of PCB180 with one ng/kg body weight increased the serum PCB180 with 32,17 ng/g lipid. Living inland reduced the serum value 23,52 ng/g lipid compared to living by the coast.

It is surprising that the model worked so well for PCB138, 153 and 180, to a certain extent for PCB118 and not at all for PCB101. This can be due to differences in half-lives, but data on this are very uncertain [5]. There is no pattern in the quantity of intake of the congeners that can explain the differences. The differences can maybe be explained by other sources than food for PCB 101 and 118.

In conclusion we can say that this model predicts the serum PCB138, 153 and 180 from dietary intake estimates, explaining between 52 to 65 % of the variance.

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