



Factors that predict serum PCB concentrations in Michigan, USA

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Introduction

- We studied factors that predict serum concentrations of the polychlorinated biphenyls (PCBs) for which World Health Organization (WHO) Toxic Equivalency Factors exist (PCB 77, PCB 81, PCB 126, PCB 169, PCB 105, PCB 114, PCB 118, PCB 123, PCB 156, PCB 157, PCB 167, and PCB 189) using data from participants in the University of Michigan Dioxin Exposure Study (UMDES) in Midland and Saginaw Counties, Michigan, USA.
- Although the UMDES focused on PCDD and PCDF exposures, PCBs were also measured to calculate TEQs, even though these compounds were not thought to have originated appreciably from the Dow Chemical Co. operations in Midland, MI. Thus, this study provides a valuable opportunity to identify potential environmental exposure pathways for PCBs.

Methods

- Subjects were randomly selected from the populations of 5 counties in Michigan. Midland, Saginaw, and part of Bay Counties were chosen for their proximity to the Dow Chemical Co. and Jackson and Calhoun Counties were chosen as a reference population. 1324 adults age 18 years and over who had lived in their current residence for 5+ years participated, of whom the 946 who were interviewed and gave blood samples are included in this analysis.
- Serum, house dust, and soil were analyzed for the 12 PCB congeners with dioxin-like activity. Samples below the limit of detection were estimated using LOD/√2. Serum results are lipid adjusted and survey weighted to reflect the entire referent population region.
- A forward stepwise selection procedure was used to identify significant predictors of the log10 serum PCB concentration. Five multiply imputed data sets were used in each step, adjusted for sample design features (sampling weights, stratification, clustering). In the first phase, age, age², BMI, sex, breast feeding, smoking, region, PCB concentration in soil around the house (top 1 in), and PCB concentration in garden soil were forced into the model since they were either important predictors from preliminary models or addressed the principal hypotheses. We then fit a model on the forced-in variables, allowing the variable with the smallest combined p-value to enter at each step, and refit the model. The combined p-value was calculated using Rubin's multiple imputation combining rule, averaging the regression coefficients and accounting for between and within imputation variations. Variables entered might be dropped if they were no longer significant as other variables were added. The stepwise procedure continued until the combined p-values for all variables in the model (except for those forced in) were significant (p<0.05).
- Influential observations were examined. Explanatory variables were removed from the model if they were unstable (i.e., significance dependent on ≤ 3 observations).

Results

Linear Regression Results (Table 1)

- Serum PCB concentrations were detectable in greater than 98% of subjects for all congeners except PCB 81.
- Overall model:** explained 79% of the variance in serum PCB 169, 44% for PCB 126, 28% for PCB 81 and 11% for PCB 77.

Table 1: Percent variation in serum concentrations (adjusted R²) explained by category of factors

Contribution to Adjusted R ²	PCB77	PCB81	PCB126	PCB169
Overall (Stable only)	10.92	28.18	43.90	79.01
Demographic and Health factors	6.69	18.66	31.16	60.62
Residence factors	0.00	-0.22	0.18	0.00
Soil/House dust	0.33	0.89	0.00	0.00
Property use factors	1.36	0.68	1.03	0.50
Work history factors	0.00	0.00	0.18	0.12
Water activity factors	0.75	6.62	0.00	0.00
Fish consumption and fishing	0.25	1.96	2.46	0.98
Meat/dairy consumption and hunting	0.02	0.37	-0.05	0.81

- Demographic and health factors** were the most important predictors of all PCB congeners, explaining 61%, 31%, 19%, and 7% of the variance in the serum PCB 169, PCB 126, PCB 81, and PCB 77, respectively.
- Current residence** (in Midland/Saginaw) versus Jackson/Calhoun explained little of the variation in serum PCB concentrations
- Soil and house dust** explained less than 1% of the overall variation in each PCB congener.

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Results, cont.

Linear Regression Results (Figures 1-4)

- Age² was positively associated with serum PCB 77. Age was associated with serum PCB 81 and PCB 126, and age and age² were associated with PCB 169. Serum PCB concentration rose modestly with age for PCB 81 and more dramatically for PCB 126 and PCB 169.
- Sex was not a significant predictor of PCB 77, 81, or 129, whereas it was for PCB 169, with females having lower levels than males at all ages.
- There is a complex relationship between body mass and serum PCBs and BMI loss is associated with higher serum PCB concentrations. BMI showed no relationship with PCB 77, but there was a negative relationship between BMI and serum PCB 169. A gain in BMI was inversely associated with PCB 81 and a loss of BMI was positively associated with PCB 129.

Figure 1: Relationship between serum PCB 77, age and sex

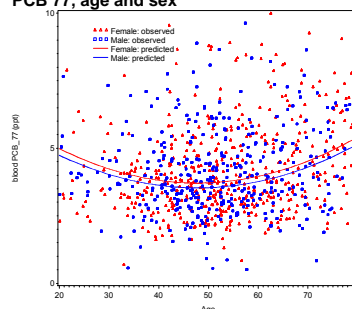


Figure 2: Relationship between serum PCB 81 and age and BMI gain

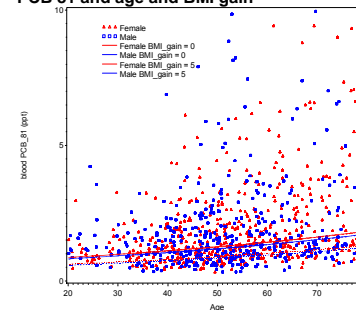


Figure 3: Relationship between serum PCB 126 and age, sex and BMI loss

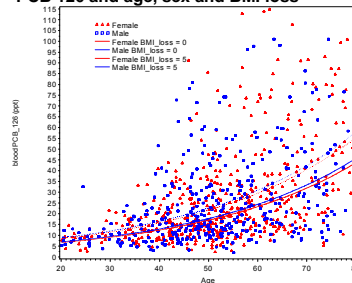
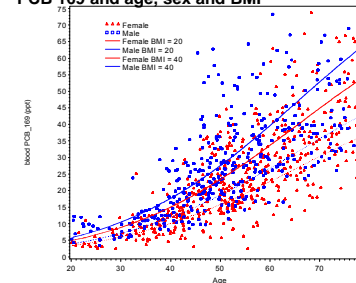


Figure 4: Relationship between serum PCB 169 and age, sex and BMI



- Smoking was inversely associated with serum PCB 81 and PCB 126, but not PCB 77 or PCB 169.
- Living in the floodplain was associated with higher PCB 81. Living in the Near Floodplain was associated with higher PCB 126.
- Household dust PCB 77 concentration was associated with serum PCB 77, whereas dust PCB 81 loading was associated with serum PCB 81.
- Living on a farm in 1940-1959 was associated with increased serum PCB 126 and PCB 169.
- Eating fish in the past 5 years from the contaminated water bodies gave inconsistent results.
- Hunting and eating game from the contaminated area gave inconsistent results. Eating deer liver from any location was associated with increased PCB 169.

Conclusions

- Demographic factors, especially age and changes in BMI, are important predictors of serum PCB levels.
- This study was large and capable of finding small statistically significant associations. Inferences should include consideration of the magnitude of the effect, the statistical significance of the estimate, and the variance in serum PCB explained by the factor.